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INITIAL BAC DATE 7/28/05

TABLE III-17

RADIOACTIVE LIQUID WASTE DISCHARGES RECORD TO 1974[a]

	ANL		CFA		ICPP		NRF		PBF/SPERT		TAN		TRA		TOTAL	
Year	Volume	Curies	Volume	Curies	Volume	Curies	Volume	Curies	Volume	Curies	Volume	Curies	Volume	Curies	Volume	Curies
1952			NA	NA									19	63	NA	63
1953			NA	NA	1,298	16	10	<1					59	216	1,308	232
1954			NA	NA	890	10	38	1					360	1,141	928	1,152
1955	<1	10	NA	NA	1,522	20	36	5					370	1,242	1,927	1,277
1956	<1	1	NA	NA	1,352	27	41	3	<1	<1			359	839	1,753	869
1957	<1	<1	NA	NA	893	289	46	5	<1	<1			390	962	3,446	1,256
1958	<1	<1	NA	NA	1,439	343	54	31	<1	<1			943	3,073	2,437	3,447
1959	<1	<1	NA	NA	1,271	60	64	9	3	155	64	11	706	4,628	2,107	4,863
1960	<1	<1	116	<1	726	36	85	31	2	<1	55	2	838	3,439	1,823	3,508
1961	2	<1	144	<1	712	625	93	31	1	<1	186	<1	888	3,863	2,026	4,519
1962	18	<1	167	2	1,009	407	106	41	1	<1	110	<1	1,072	1,288	2,484	1,738
1963	<1	<1	182	2	982	1,117	103	57	2	<1	186	<1	765	1,258	2,221	2,434
1964	<1	<1	184	1	1,307	1,792	103	32	5	<1	119	3	650	848	2,369	2,676
1965	<1	<1	221	5	1,581	116	125	25	8	<1	84	<1	552	616	2,569	763
1966	<1	<1	258	2	1,380	265	140	18	19	<1	105	<1	494	910	2,395	1,195
1967	<1	2	173	2	1,140	870	133	9	13	<1	74	<1	687	1,024	2,220	1,907
1968	<1	<1	160	<1	1,987	516	144	13	8	<1	70	10	712	792	2,118	1,331
1969	<1	3	281	2	1,240	163	117	16	4	<1	119	10	1,060	3,262	2,821	3,456
1970	<1	3	379	2	1,051	81	76	12	8	<1	53	3	1,060	4,474	2,635	4,575
1971	<1	<1	149	<1	1,050	62	40	4	2	<1	85	5	829	2,406	2,155	2,971
1972	<1	<1	159	<1	1,287	308	5	<1	1	<1	80	6	821	1,397	2,353	1,711
1973	<1	<1	175	<1	1,299	34	2	<1	<1	<1	97	5	1,017	1,518	2,591	1,557
1974	<1	<1	118	<1	1,456	458	2	2	<1	<1	51	2	932	1,786	2,559	2,248
Total	20	19	2,865	18	25,870	7,615	1,565	345	76	155	1,539	57	15,552	41,049	47,150	49,745

[a] Volume in million liters (multiply by 0.2642 to convert to gallons). Details may not add up to totals because of rounding.

TABLE III-18

LIQUID NUCLIDE SUMMARY IN CURIES FOR 1974

Nuclide [a]	Half-Life	ANL	CFA	CPP	NRF	PBF	TAN	TRA	Total [b]
Barium/lanthanum-140	13 days/40 hr							1.8	1.8
Barium-140	13 days							1.8 (1)	1.[illegible] (1)
Carbon-14	5730 yr			1.9 (-2)	3.9 (-4)				1.9 (-2)
Cerium-141	32 days							[illegible].9	[illegible].9
Cerium-143	33 hr							9.3 (-1)	9.3 (-1)
Cerium-144	284 days		3.8 (-3)	2.5 (-2)				1.4 (1)	1.45 (1)
Cobalt-58	72 days				3.6 (-7)			1.0 (-1)	1.0 (-1)
Cobalt-60	5.3 yr		9.6 (-3)	6.4 (-3)	5.3 (-5)		3.3 (-4)	2.9	2.95
Chromium-51	28 days							1.3 (2)	1.34 (2)
Cesium-134	2.3 yr		1.4 (-3)	5.0 (-2)	2.6 (-7)			[illegible]	1.1
Cesium-137	30 yr		2.4 (-2)	6.5 (-1)	1.3 (-5)		5.7 (-4)	[illegible]	4.[illegible]
Hafnium-181	46 days							[illegible] (-1)	[illegible] (-1)
Iodine-129	1.56 (7) yr [c]							[illegible] (-3)	2.4 (-3)
Iodine-131	8 days							2.7 (1)	2.7 (1)
Iodine-132	2.3 hr							2.8 (-1)	2.8 (-1)
Iodine-133	21 hr							2.9	2.9
Iodine-135	6.7 hr							6.2 (-2)	6.2 (-2)
Iron-59	45 days							2.8 (-3)	2.8 (-3)
Lanthanum-140	40 hr							6.7	6.7
Lutetium-177	6.7 days							9.2 (-1)	9.2 (-1)
Manganese-54	300 days							6.4 (-2)	6.4 (-2)
Niobium-95	35 days			3.5 (-3)				1.9	1.93
Plutonium-238	89 yr			1.7 (-2)					1.7 (-2)
Plutonium-239	2.4 (4) yr			4.[illegible] (-3)					4.[illegible] (-3)
Plutonium-239/240	2.4 (4) yr/6760 yr			5.7 (-4)					5.7 (-4)
Ruthenium-103	40 days							7.0	7.0
Ruthenium-106	368 days		3.6 (-3)	5.7 (-1)			1.[illegible] (-5)	1.1 (-1)	6.8 (-1)
Sodium-24	15 hr							4.1 (1)	4.1 (1)
Strontium-89	50.5 days							1.4 (1)	1.4 (1)
Strontium-90	28.9 yr	3.3 (-6)	2.51 (-2)	2.0 (-1)			3.6 (-3)	2.9	3.[illegible]
Tritium	12.3 yr	[illegible] (-2)		4.5 (2)	1.6	6.4 (-3)	2.2	[illegible] (2)	6.[illegible] (2)
Unidentified alpha	-	[illegible] (-9)	2.0 (-3)		3.4 (-7)	1.2 (-5)	2.0 (-4)	1.4 (-1)	1.[illegible] (-1)
Unidentified beta and gamma	-	2.0 (-6)	1.1 (-1)	3.6 (-1)	5.3 (-4)	5.3 (-4)	2.5 (-5)	[illegible] (1)	2.5 (1)
Zirconium/niobium - 95	65 days/35 days							1.[illegible]	1.3 (-1)
Zirconium - 95	65 days			2.6 (-4)				5.3	5.3
Total		2.97 (-2)	1.75 (-1)	4.57 (2)	1.6	6.9 (-3)	2.23	1.785 (3)	2.244 (3)

[a] Does not include several radionuclides with short half-lives and activities less than one Curie, i.e., Antimony-122, -1[illegible], [illegible], Strontium-91, -92, etc.

[b] Details may not add up to totals because of rounding

[c] $1.56\ (7) = 1.55 \times 10^7$

amounts subsequently have been reduced by decay; for example, the 2,248 Ci reported during 1974 were reduced to 684 Ci through the process of radioactive decay by the end of the year. As a typical qualitative composition of the waste, the nuclides which contributed the activity during 1974 are shown in Table III-18.

The seepage ponds to which waste from the TRA establishments is discharged have been described previously (see Section II.A.7). Waste solutions from the water treatment processes and cooling towers originally were discharged to the same pond as the low-level radioactively contaminated liquids. The water process wastes were sent to a separate pond beginning in 1962, and the cooling tower wastes to a well in 1964.

Low-level waste at ICPP is discharged directly to the groundwater aquifer system via a 598-ft-deep well, the bottom of which is 140 ft below the top of the water table. About 47 million gallons from a fuel storage basin were discharged to a seepage pit between 1954 and 1966. This contained about 500 Ci including 380 Ci of tritium, 33 Ci of strontium-90, 34 Ci of cesium-137, plus other nuclides of minor consequence[81,82,83,103].

Waste from the NRF reactors and fuel handling facility has been discharged to a seepage pond backfilled with coarse gravel or rock. The amount of waste discharged is insignificant when compared with that of TRA and ICPP.

Discharge at other locations also has been quite small when compared with that at TRA and ICPP; for example, discharge at TAN was made via four wells. Only one was ever used to any extent, and discharge to this well was directed to a diked 35-acre area in 1972, together with effluent from the sewage treatment plant. An excavated pond covering about 2.3 acres has been provided for future LOFT operations. Concentrations of all radionuclides, except tritium, will be less than 0.1% of the Drinking Water Guides[40].

The ANL area originally involved the now retired EBR-I, southwest of CFA. The EBR-II in the southeast corner of INEL is presently active, and discharge is to a seepage pit excavated in basalt.

Liquid waste from CFA is contaminated by laundry and laboratory waste. It is released to the sanitary sewage system consisting of a treatment plant and a subsurface drainage field.

Other establishments such as OMRE, SL-1, and SPERT discharged small amounts to ponds before being retired or dismantled[a].

c. Land Commitment and Impact

Discharge of waste via a well commits only that surface area required for pipelines leading to the wellhead structure. The structure usually requires less than 50 ft^2. The waste is dispersed at depths

[a] Additional details are found in Section X, Part X.16.9.

below the regolith; consequently, the soil is not contaminated by the accumulation of contaminants carried in the waste streams. At such time as discharge is discontinued, the lines, casing, and wellhead structure can be removed and the vegetative cover restored without any residual consequence to the land.

In the case where waste streams are discharged to ponds, the use of land involves the actual area of the water, surrounding marginal areas, and contaminated subsoils which may have to be dedicated for an indefinite period of time.

At TRA the surface pond area encompassed by the fence, the marginal area, and the contaminated subsoils involve about 6.5 acres. A retention basin in the discharge line has leaked and contaminated the subsoil over an area of about 2 acres. At NRF about 4 acres are involved. The two ponds at TAN which are planned for future use cover about 37 acres. Small pond areas at SPERT, OMRE, GCRE, and ANL, which are no longer used, amount to about 2 acres; however, very little radioactivity was discharged to these ponds, and the contamination is inconsequential. An area of less than 1 acre is involved by the subsurface drainage area associated with the CFA sewage treatment plant. Areas near the ponds may be contaminated to a detectable extent as a result of wind erosion. The pit into which the waste from the ICPP fuel storage basin was discharged contaminated an area of less than 1 acre. (This area has subsequently been excavated and occupied by a new building.) In summary, a total of 52 acres has or will be utilized for radioactive liquid waste discharge and can be considered permanently dedicated.

d. Water Resource Commitment and Impact

The effect of INEL operations on the water resource is related to quantity and quality. The volume pumped from beneath INEL has ranged from 1.37 billion gallons in 1963 to 2.878 billion gallons in 1974 with a mean for the 15-yr period (1960-1974) of about 2 billion gallons. This is equivalent to about 6,000 acre-ft, or the quantity necessary to annually irrigate 1,500 acres -- depending on soil, crop, irrigation efficiency, and management. At a common rate of domestic use of 150 gallons per capita per day, 2 billion gallons would be equivalent to the amount used by a city with a population of 40,000.

The estimated flow beneath INEL is 4.7×10^{11} gallons/yr[76]. The annual volume discharged by the aquifer into the Snake River by springs and to the land by irrigation wells is estimated at 2×10^{12} gallons. About one-half of the water pumped from the aquifer at INEL is returned; therefore, the actual amount consumed represents about 0.2% of the flow under INEL and less than 0.1% of the aquifer discharge. Consequently, the quantitative effect of INEL operations on the water resource is relatively minor.

About 20% of the water pumped at TRA eventually becomes radiologically contaminated. As of 1974, a total of 4 billion gallons (1.5×10^{10}

liters) has been discharged into seepage ponds. This volume of water contained a gross concentration of 2.7 x 10^{-3} μCi/ml of radioactive contaminants at time of discharge; 90% of these contaminants were short-lived (less than 30-day half-life). The residual curie amounts in 1974, after decay, were estimated as: strontium-90 - 68 Ci; cesium-137 - 100 Ci; and cobalt-60 - 72 Ci.

As a means of studying the environmental effect of this discharge, laboratory models were used to simulate movement of the waste. This analysis indicated that the strontium retention capacity of the minerals in the regolith below the pond had been filled[104]. The waste solution seeps below the gravel, then spreads until it encompasses an irregularly shaped subsurface area as shown in Figure III-30. As it continues to percolate down to the water table 400 ft below, the waste water passes through strata of soil-like, unconsolidated material in the basalt. These sedimentary beds average 80 ft in thickness in a zone about 300 ft thick (from 150 to 450 ft below the surface of the pond). About 25% of the material in this zone is sedimentary. These sedimentary beds are considerably finer grained than the surface alluvial sandy-gravel layer and have a higher sorptive capacity. The capacity of these underlying materials to "sorb" strontium apparently has not been exceeded, which explains why strontium isotopes have not been detected in water samples taken from wells which penetrate the regional aquifer. A recent study[104a] estimates that basalt and the included fracture fillings in basalt have an average sorptive capacity of about 5% of the average sorptive capacity of sediments. The specific sorptive capacity of basalt is much lower than sediments but it becomes important because of the relatively greater thickness of the basalt. This study[104a] evaluates the past, current and future conditions with the TRA pond substrata. A three segment numerical model was used to simulate this system. It was concluded that strontium-90 would not reach the Snake River Plain aquifer in detectable concentrations within 150 yr, for the conditions assumed.

The retention capacity of the surface gravels (regolith) for cesium is greater than for strontium, and this capacity is far from being depleted. For example, the total capacity is estimated at 2,500 Ci in comparison with the 100 Ci involved in the discharge.

The recent study[104a] of the retention of cobalt-60 beneath the TRA ponds indicates that cobalt-60 should behave similarly to strontium-90 except that it decays faster. Cobalt-60 distributions mapped from field data indicate that cobalt-60 may be a little more mobile than strontium-90. However, for the conditions assumed, the shorter half-life of cobalt-60 would ultimately prevent measurable concentrations from entering the Snake River Plain aquifer.

Cerium-144 concentrations have not been determined or mapped in the perched water beneath the TRA ponds. The sorptive capacity for cerium-144 is apparently higher than that for strontium-90 in the sediments at TRA. Sorption and a relatively short half-life of cerium-144 prevent any measurable quantities from entering the Snake River Plain aquifer.

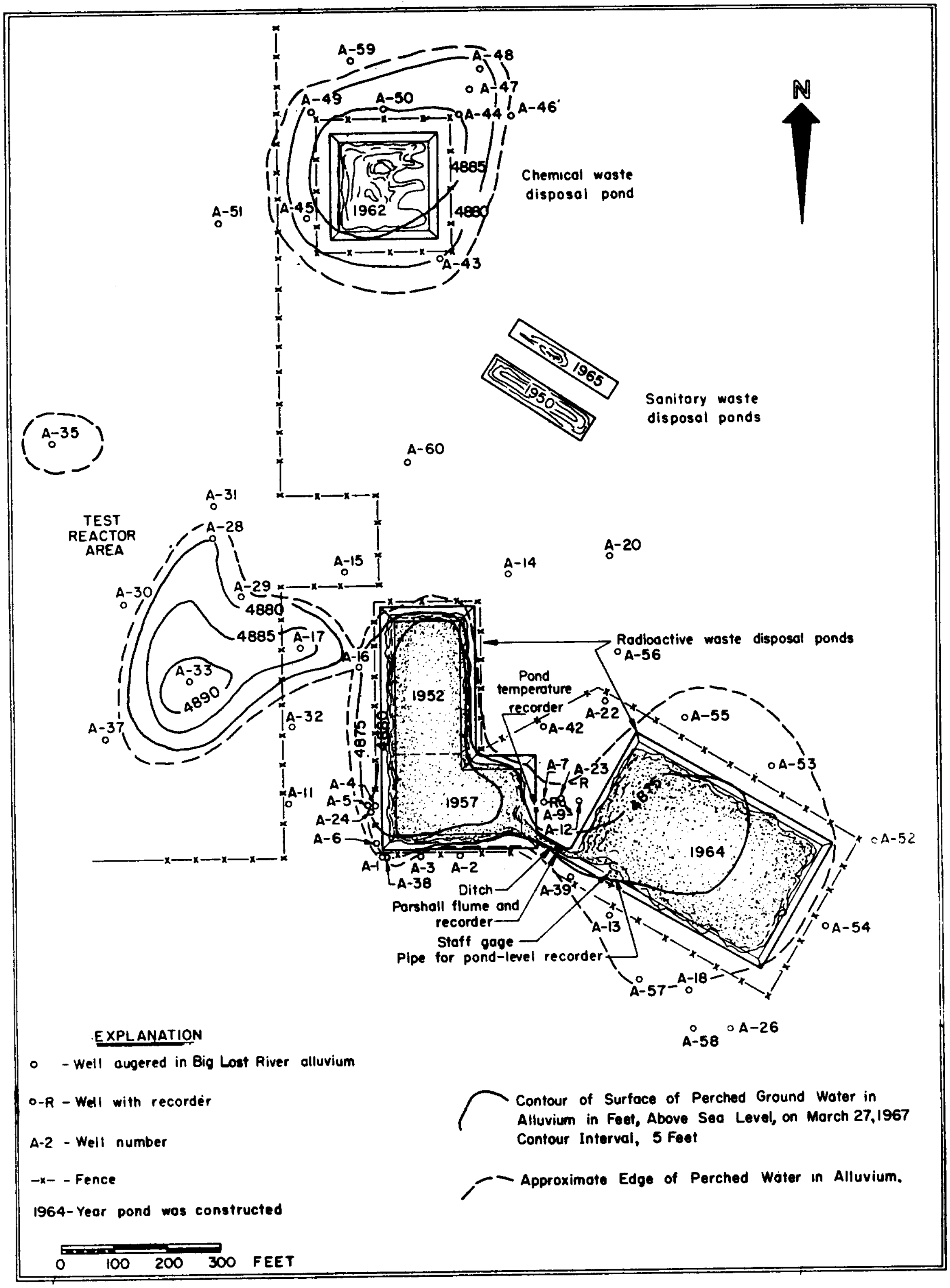

Figure III-30. Sketch Map of TRA Pond Areas Showing Water Level Configuration in Regolith.

Field investigations were conducted in 1968 and 1970 to supplement the laboratory modeling findings[104]. Samples of earth materials were obtained from below the pond. These confirmed that the strontium retention capacity of the gravelly regolith had been reached; however, more strontium was being retained than had been indicated by the laboratory tests. No residual cesium was found more than 12 in. from the bottom of the pond, which confirmed that the regolith still had a reserve capacity.

More residual cobalt-60 was found than had been projected.

Tritium discharge to the TRA pond has accounted for about 10% of the gross activity at INEL since 1961. On this basis, it has been estimated that approximately 6,000 Ci of tritium have been discharged since 1952. Allowing for decay, about 4,400 Ci would remain[76]. These relatively large quantities, plus the character of tritium, provided a useful tracer in investigating the environmental effects of waste discharge.

Figure III-31 shows the distribution of tritiated water in the perched zone in the basalt as of April 1970[76]. This sketch indicates the distribution of the water after it leaves the ponds, and before it enters the regional aquifer. As tritium is not subject to sorption and as dispersion should have reached a point of diminishing effect, the explanation for the decrease in concentration is a matter of conjecture. The recharge from the Big Lost River is believed to have a significant influence. Decay (tritium half-life of 12.3 yr) accounts for only a small part of the reduction. The hydrodynamics of the system may also be a factor; e.g., the water around the outer edge may be old water which is not being replaced by more recent discharges. The fresh water may be percolating downward in the central part of the perched zone before it moves laterally outward, thus allowing the tritium in the older water around the edge to decay.

The sketch suggests a southeast direction of movement and a depletion gradient of about 1,000 to 100 pCi/ml in 3,200 ft. As the areal extent of the zone of saturation does not increase appreciably, it is inferred that the input is equal to the seepage rate. Tritium is the only radionuclide detected in aquifer samples taken in the vicinity of TRA. Its distribution is shown in connection with the following discussion relative to ICPP.

About 90% of the water pumped from the ground at ICPP is returned by means of a well. The yearly average volume is 300 million gallons/yr with a mean content of about 350 Ci/yr. Between 85 and 95% of the activity has been contributed by tritium. About 20 Ci each of strontium-90 and cesium-137 have been discharged to this well. For many years radioactive contaminants could not be detected in the groundwater, and the movement of the waste streams was traced initially by analysis of water samples for sodium and chlorine ions resulting from common salt solutions discharged with the radioactive contaminants. As more experience was gained additional techniques were employed such

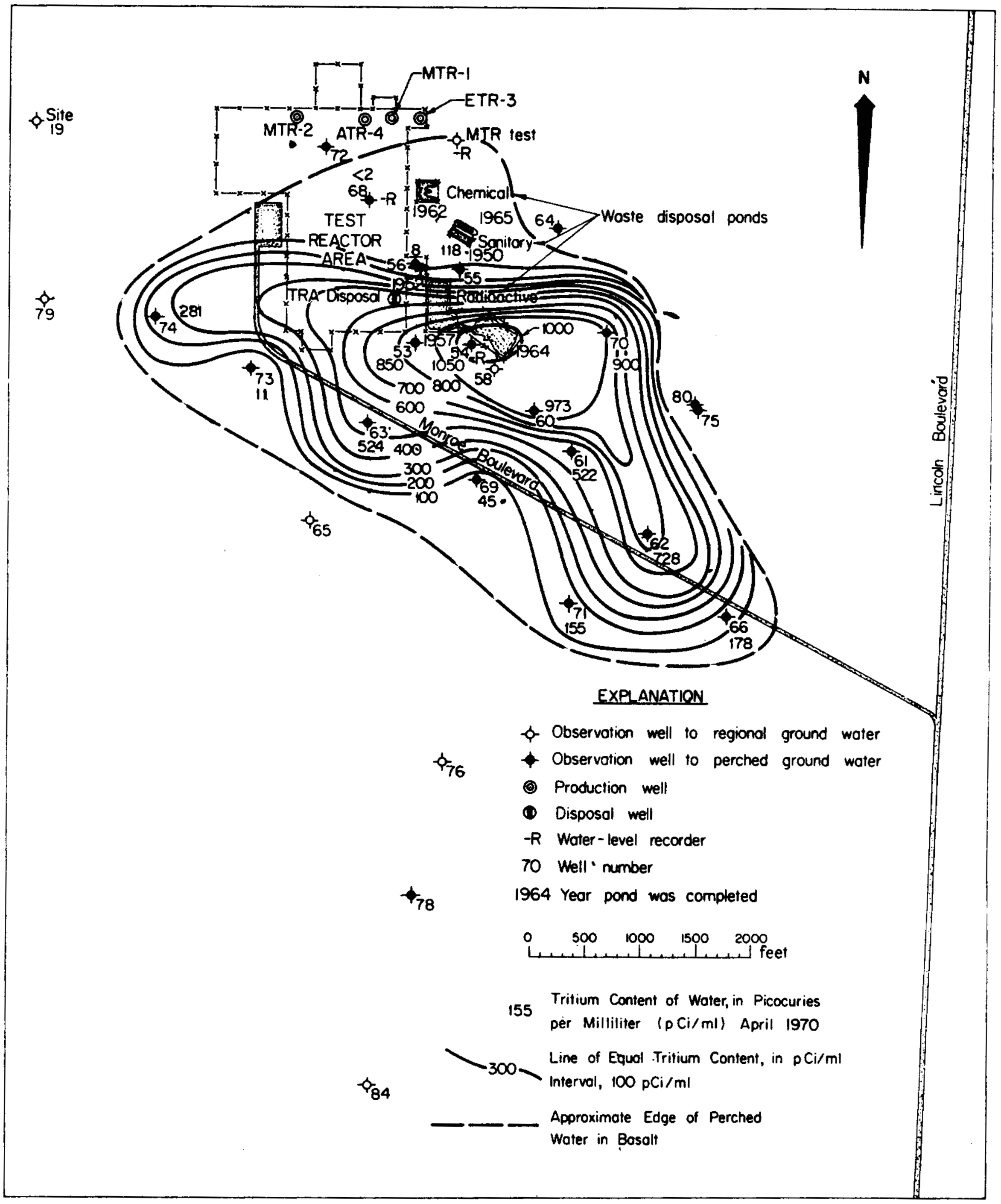

Figure III-31. Sketch Map of TRA Showing Extent of Tritium in Perched Water Below Sand -- April 1970.

as analysis for tritium and other contaminants, determination of temperature differentials, and specific conductance. The aquifer system was defined in more detail by such techniques as borehole geophysics, aquifer isolation, pumping, and tracer tests. Thus, the natural factors controlling the movement and behavior of the wastes were defined. This included direction and velocity of groundwater flow, dispersion properties of the aquifer, degree and distribution of anisotrophy and heterogeneity, sorption and heat transfer properties, and chemical equilibria. This work has been summarized in a recent report[76]. Briefly, the effects of waste now can be detected over a 15-mi^2 area down gradient from the discharge well and for longitudinal distance of about 5 mi, which is still well within the boundary of INEL.

Only four nuclides, plutonium, iodine-129, strontium-90 and tritium, are detectable in the Snake River Plain aquifer over a significant area of distribution. Plutonium-238, plutonium-239, and plutonium-240, have only recently been detected in the vicinity of the ICPP disposal well (740 ft down gradient). Mean concentrations of 0.65×10^{-11} μCi/ml plutonium-238 and 0.24×10^{-11} μCi/ml of plutonium-239, -240 have been identified in the aquifer at this point [104b]. These concentration values are about two million times lower than federal and State of Idaho concentration guides for drinking water used continuously by the public.

Iodine-129 has also recently (1974) been detected in the aquifer. The highest concentrations of iodine-129 found were in samples taken from a well about 703 ft down gradient from the ICPP disposal well, and were less than one-tenth the concentrations permitted by state and federal regulations for water used continuously by the public. The farthest distance from ICPP that iodine-129 has been found in detectable concentrations is 6,300 ft. A sampling and analysis program is continuing to define the iodine-129 distribution in the aquifer.

Strontium-90 was detected in the aquifer in 1964 near the ICPP disposal well. Figure II-32 illustrates the distribution as of 1970. In 1964, the highest concentration was measured at 0.06 pCi/ml. The maximum concentration rose to about 0.2 pCi/ml. (The recommended concentration guide for strontium-90 in drinking water is 0.3 pCi/ml for an uncontrolled area[7]). The possibility has been considered that a discharge during 1962 and 1963 of 32 Ci of strontium-90 to a pit near the fuel storage facility at the southern end of the ICPP area could have contributed to this rise in stronium-90 beginning in 1964. The volume of water, which also contained 32 Ci of cesium-137, was more than could be absorged and it seeped into the underlying basalt. It is estimated that only 6 Ci of the strontium would have been retained by the soil and regolith, which since have been removed to make way for a new building[104].

Since tritium is the most abundant component in INEL radioactive liquid waste effluents, its presence in the aquifer has been used as an indicator of the effects of discharge. By 1961 tritium had reached CFA about 3 mi from the disposal well. The highest concentration within the distribution plume was 700 pCi/ml. By 1968, the plume from liquid waste discharges at TRA coalesced with the ICPP plume. Figure III-33 shows the concentrations as of 1970[76]. A materials balance (input versus aquifer inventory) has accounted for the amount of tritium discharged which indicates that no significant quantity

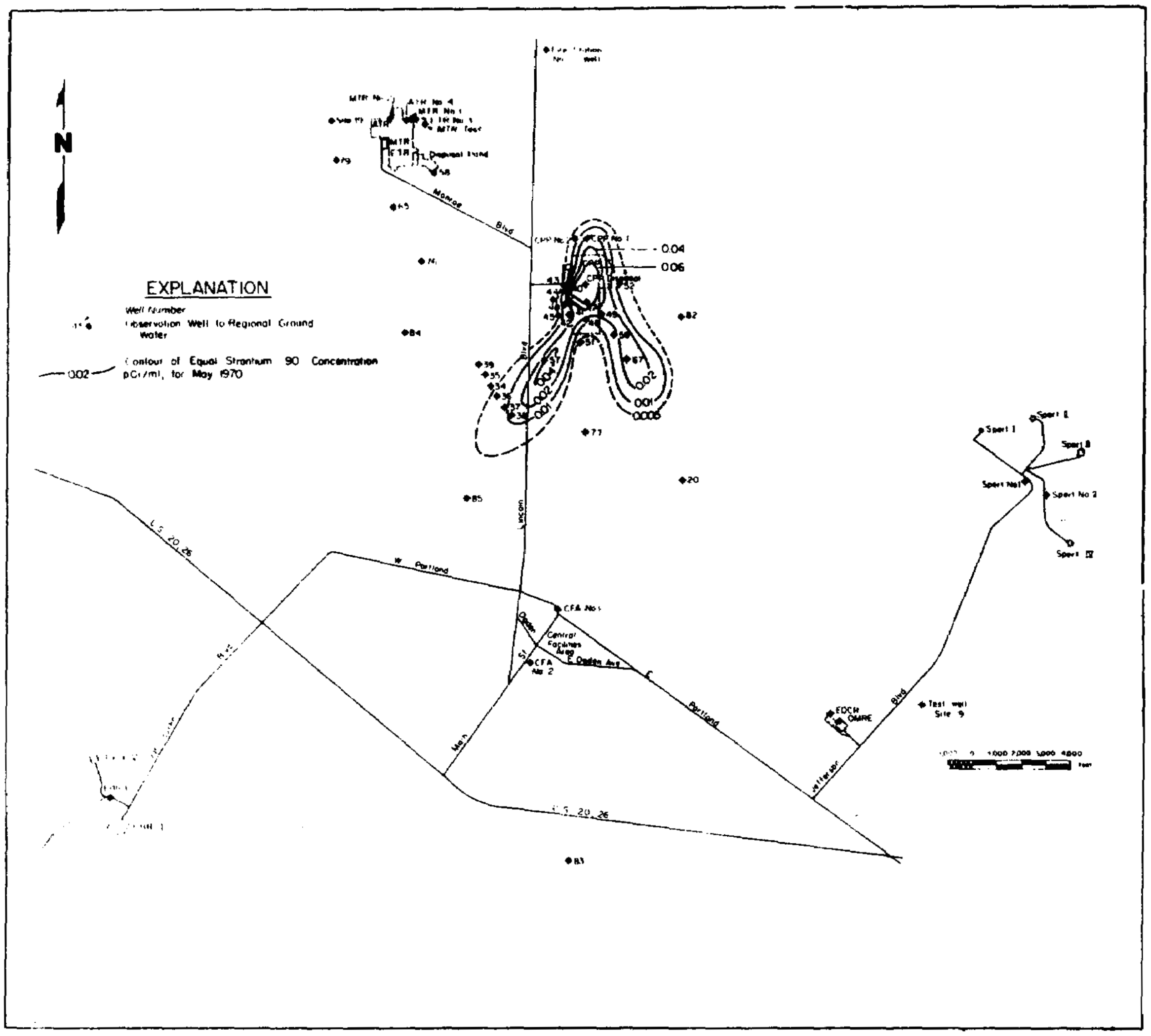

Figure III-32. Sketch of the ICPP-TRA Vicinity Showing Distribution of Strontium-90 in the Regional Aquifer as of 1970.

of waste has migrated below the aquifer thickness sampled nor escaped beyond the defined perimeter of the plume.

The distribution of tritium in the aquifer is especially significant because it is not diminished by sorption on earth minerals. Also reduction of activity by decay is relatively slow because of tritium's 12-yr half-life. Its presence is therefore indicative of the maximum distribution that might be expected for any nuclide. The tritium radioactivity concentration guide for an uncontrolled area is 3,000 pCi/ml as compared with the maximum observed concentrations of 1,000 pCi/ml and 25 to 100 pCi/ml concentration found at CFA. The water from the CFA well is used for domestic purposes. The radiation dose from drinking this water is discussed later in this section under "Impact on Man."

Digital modeling techniques have been applied to the Snake River Plain aquifer system for the purpose of predicting future changes[105].

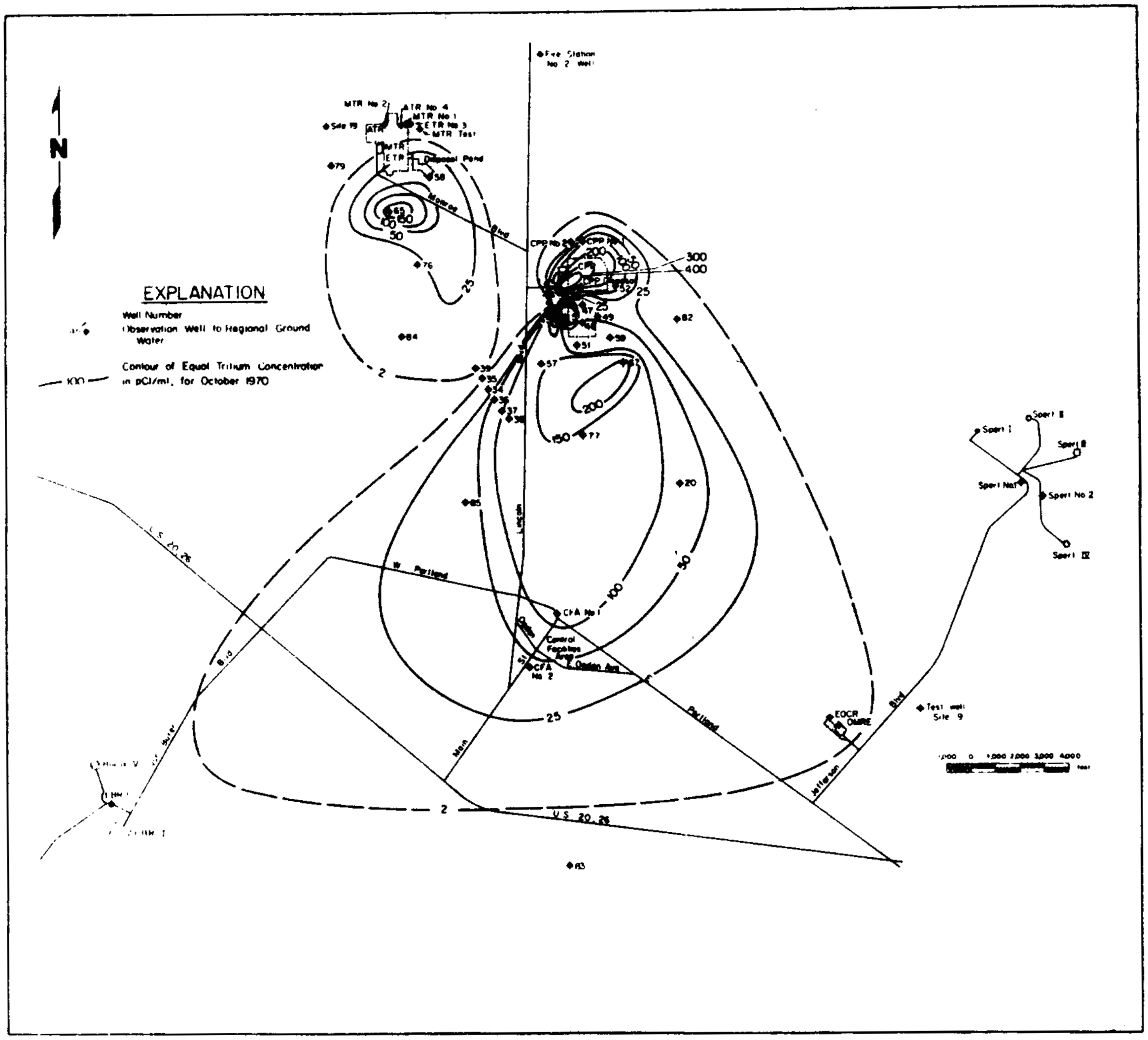

Figure III-33. Sketch of the ICPP-TRA Vicinity Showing Distribution of Tritium in the Regional Aquifer as of 1970.

One such model involves the effects of convective transport, flow divergence, two-dimensional hydraulic dispersion, radioactive decay, and sorption. Using this model, several future projections up to the year 2000 have been made for the movement of chloride, tritium, and strontium-90 under various conditions. Since chloride is neither attenuated by radioactive decay nor subject to sorption, it is used to illustrate the effect of dispersion and maximum distribution. If it is assumed for the model that waste discharges were discontinued in 1973, the simulated distribution in 1979 then would be as shown in Figure III-34. The chloride plume gradually grows bigger and more dilute as it moves and disperses down gradient. The projection of the tritium plume in the year 2000, assuming disposal continues at the current rate, is shown in Figure III-35. Shown in Figure III-36 is the tritium plume in the year 2000, assuming disposal ceased in 1973.

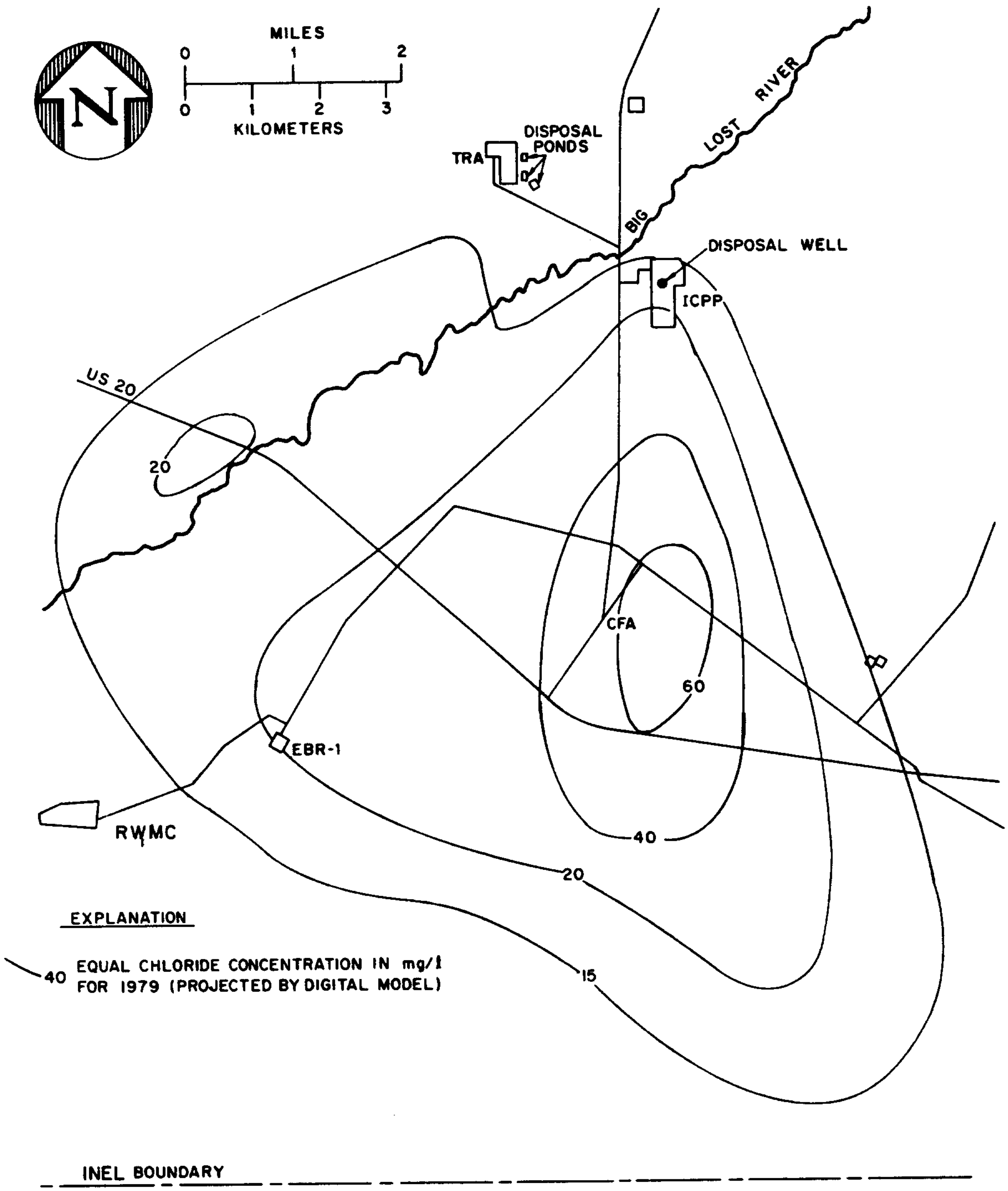

Figure III-34. Projected Chloride Plume in the Snake River Plain Aquifer for 1979 Assuming Disposal Ceased in 1973.

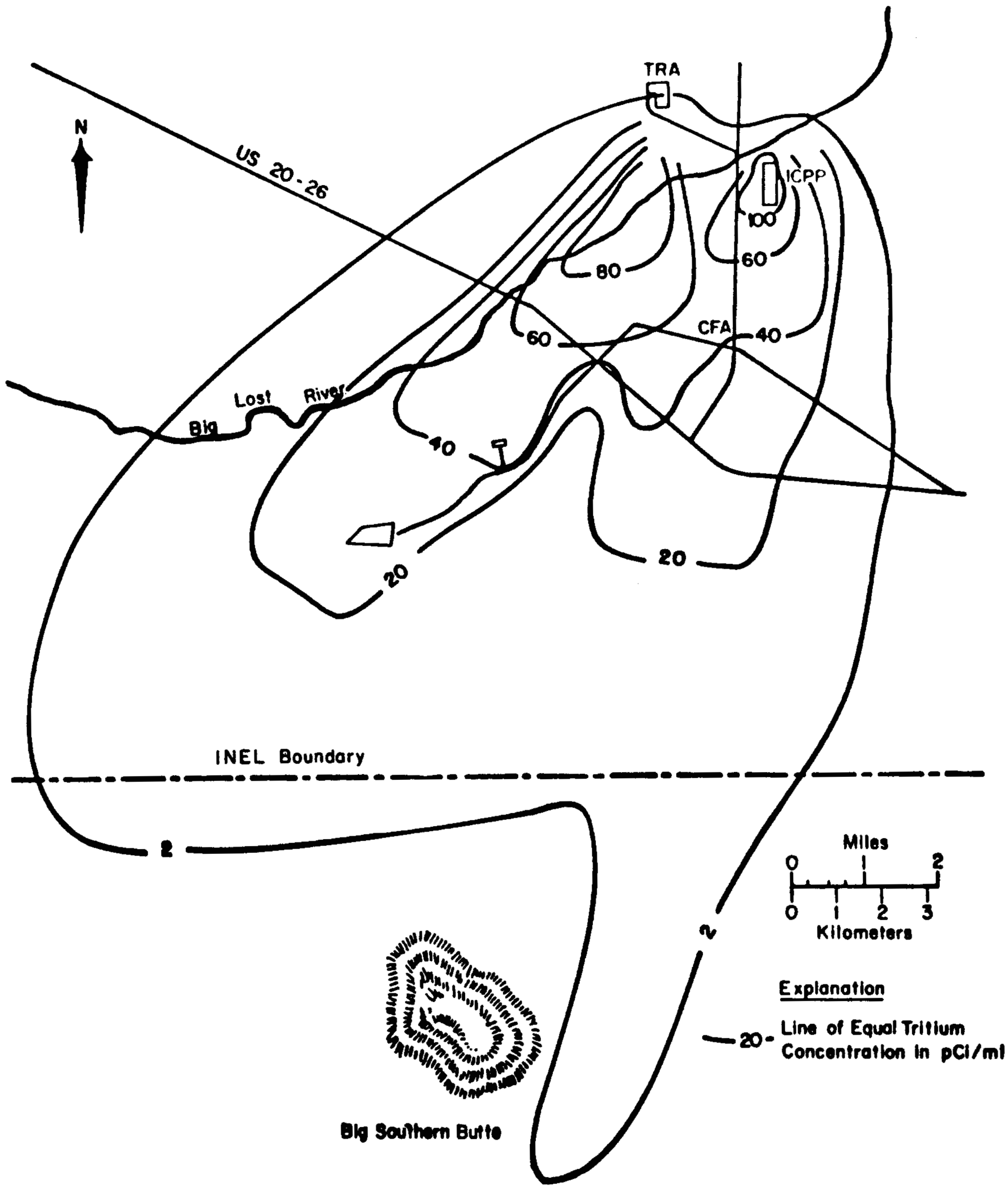

Figure III-35. Projected Concentrations of Tritium in the Aquifer in the Year 2000 Assuming Disposal Continues at the Current Rate.

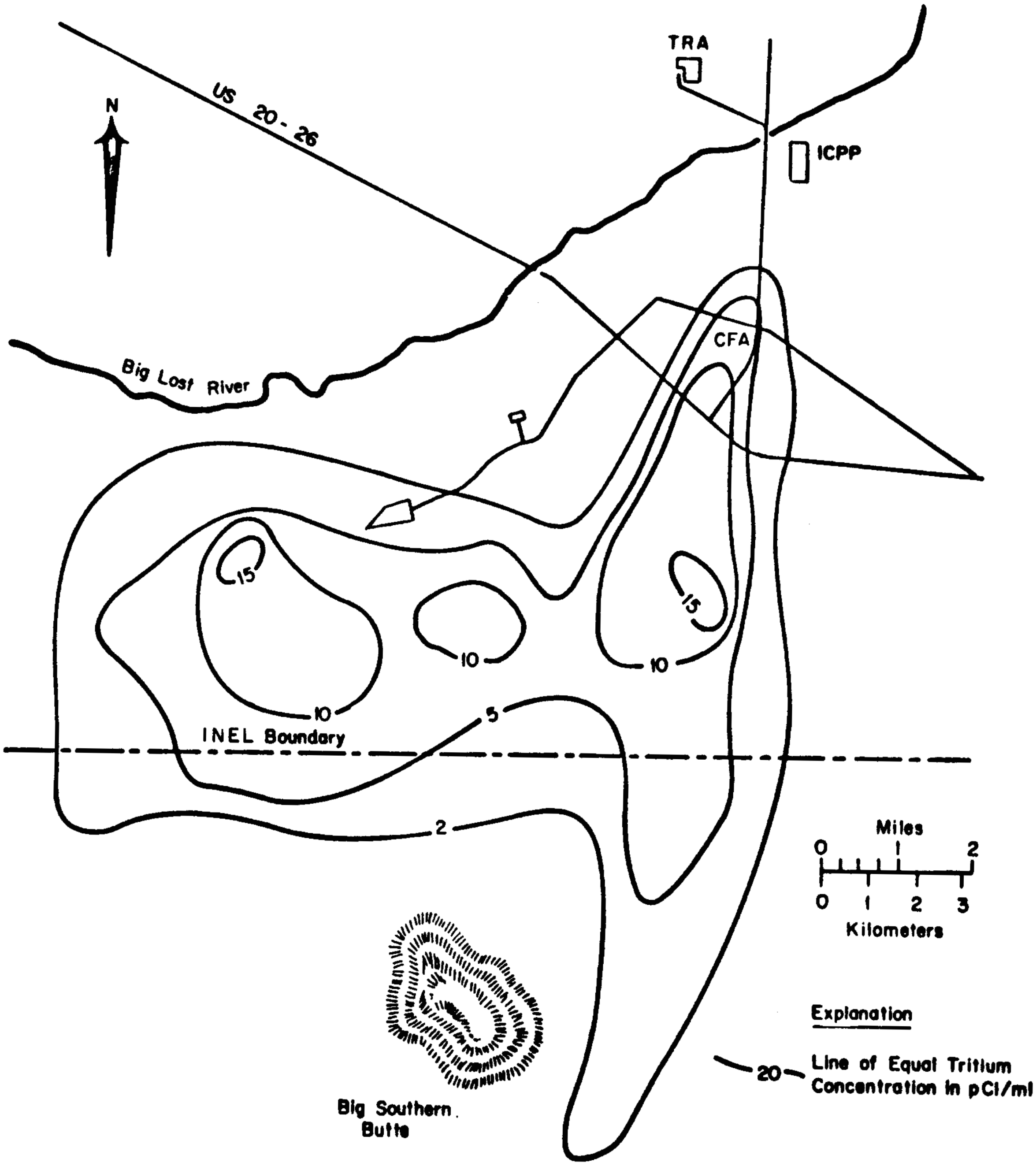

Figure III-36. Projected Concentrations of Tritium in the Snake River Plain Aquifer in the Year 2000 Assuming Disposal Ceased in 1973.

The facilities in the NRF area are currently using about 10% of the total water pumped from the aquifer at INEL. This water is used primarily for cooling, with minor amounts discharged to a sewage lagoon. Low-level radioactively contaminated liquid wastes were discharged to the ground; however, recent in-plant improvements have reduced both volumes and activity to minor amounts (5×10^6 liters containing less than 1 Ci). In 1963 the subsurface distribution of the liquid waste was examined[76]. The water, as expected, seeps to the top of the basalt where it spreads horizontally. It then percolates through the basalt sequences to the regional water table at a depth of 360 ft. Some of the production wells have shown trace evidence of the horizontal movement of the seepage. The areal distribution has not been investigated during the interval 1963 to 1973. Two monitoring wells down gradient were drilled during 1973. Analysis of a limited number of water samples from these wells has not indicated any radioactive insult to the aquifer.

CFA accounts for about 5% of the water usage, only 1% of the volume of waste discharged, and only a fraction of 1% of the activity. Other facilities use a combined total of approximately 10% of the water pumped at INEL. Inasmuch as the impact would be inconsequential in comparison with that of TRA and ICPP, CFA and the other facilities have not been investigated in detail.

e. Impact on Biota

The effect of liquid waste discharge via wells is inconsequential insofar as the biota are concerned. Very little land area is involved, and there is little destruction of plant cover; that which occurs during construction can be restored easily.

Discharge of the liquid wastes via seepage ponds involves destruction of the natural desert shrub and grass cover during construction. Following pond construction, INEL management plans ensure adequate control of plant growth around the perimeter of the pond. Control of the plant growth would have some effect on the animal life. As the area of 50 acres involved is insignificant in comparison with the 572,000 acres of INEL, this effect is considered to be very small.

Ponds serve as an occasional resting place for migrating waterfowl and as an occasional source of water for animal life. The maximum number of ducks that has ever been observed at the TRA pond is 25. Usually only 1 to 10 ducks are observed at any given time during the summer months. As the plant cover required for nesting around the ponds is limited, the area is not conducive to lingering waterfowl for prolonged periods.

Algae, composed primarily of single-celled floating or suspended members of the Desimidacae, have been observed to concentrate radioactivity from very low levels in the pond water to rather high levels in the algal aggregation[106]. For example, the strontium-calcium ratio on the algae was 51 times, and the cesium-calcium ratio 23 times, greater than the ratio in solution. One gram of wet algae from the pond produced radiation readings of 100 mR/hr at 1 cm (0.45 in.). It is not difficult to imagine a migrating duck eating several grams of this algae. While this might not be hazardous for a single or occasional feeding, prolonged ingestion by a resident bird conceivably could constitute a hazard to the duck and possibly man. Ducks have been sampled intermittently over a period of several years. Table III-19 contains data on the concentrations of radionuclides observed in edible tissue of nine ducks killed in the TRA pond area. Only cesium-137 was observed in five ducks collected from control areas about 30 mi away; the average cesium-137 concentration in tissue from these birds was 0.005 pCi/g.

TABLE III-19

RADIONUCLIDES IN EDIBLE DUCK TISSUE
TRA SETTLING POND

Nuclide	Number of Ducks Containing Detectable Quantities of Nuclide in Edible Tissue	Concentration (pCi/g of tissue) Maximum Observed	Average of Positive Results
Cerium-141	3	2.5	1.4
Cerium-144	4	390	110
Cesium-134	6	38	18
Cesium-137	9	890	220
Chromium-51	2	29	17
Cobalt-57	2	1.6	1.2
Cobalt-58	3	2.6	1.1
Cobalt-60	9	540	84
Iodine-131	4	18	9.3
Lanthanum-140	4	1.3	0.73
Manganese-54	2	0.23	0.18
Selenium-75	6	43	13
Silver-110m	1	2	-
Strontium-90	2	1.9	1.1
Zinc-65	8	1100	240

The maximum dose to man can be estimated by assuming that an individual kills a contaminated duck and eats 1 lb of tissue containing the highest concentrations shown in Table III-19. The whole body dose commitment would be approximately 25 mrem; the thyroid dose commitment would be about 20 mrem. This can be compared with the annual dose of 20 mrem from the naturally occurring potassium-40 within the body of man.

A study was conducted near the TRA pond and at a smaller pond at GCRE to determine the contamination of mourning doves which were thought to be utilizing low level waste water. Several doves were collected during each summer month and compared with others collected in the foothill area 30 mi away. Each specimen was analyzed for gross gamma emitting nuclides, skinned, and envisERATED, and different body portions were analyzed for contamination. Low levels of cerium-144, ruthenium 106, and zirconium-95 were detected in the skin and feathers of doves frequenting the TRA pond, but radioactivity in body tissue from offsite doves was not significantly different from doves taken at the TRA pond[107].

f. Impact on Man

Radioactive waste products deposited on the surface of the earth or in water can be hazardous to humans as a result of external radiation or by inhalation or ingestion. Discharge of low-level wastes to the groundwater via a well results in no radiation exposure to offsite personnel, and dilution is accomplished by dispersion. The groundwater system has no biological, physical, or chemical reactions which would cause a reaccumulation. Water is pumped from the aquifer at offsite locations and used for irrigation. However, radionuclides in the liquid phase have not moved and are not postulated to move beyond the INEL boundary in detectable concentrations; no impact therefore exists in this regard.

As previously described, low concentrations of tritium, strontium, plutonium and iodine-129 have been detected in the groundwater in the immediate area and down gradient of the point where these isotopes are discharged directly to the aquifer. During 1974, at the point of discharge into the aquifer, the concentrations of tritium, strontium-90, plutonium-238, plutonium-239, and plutonium-240 were 10%, 45%, 0.02%, 0.05%, and 0.008%, respectively, of the maximum allowable value for release to uncontrolled areas under federal and state standards. Iodine-129 has not been detected at the point of release because of the sensitivity of the instrumentation used. However, trace quantities have been identified in the aquifer near the disposal well. USGS continually monitors the aquifer to determine the fate of released radionuclides. Tritium from INEL has not been detected farther than about 5 mi from the release point, which is 3.5 mi inside the nearest site boundary. The strontium has not been detected at distances greater than about 5 mi from the point of release, or about 7 mi inside the nearest site boundary. Plutonium has been detected up to 740 ft from the disposal well and Iodine-129 has been detected up to 6,300 ft from the well. Low levels of tritium have been detected in the drinking water from wells at both ICPP and CFA. The well at CFA, which is 5-1/2 mi inside the nearest site boundary, is down gradient from the point of release, and consistently has the highest concentration of tritium. The concentration at this well or any monitoring well is insignificant insofar as contributing to a permissible body burden (PBB). For example, the average concentration of tritium observed at the CFA production well during 1974 was 70 pCi/ml. A person drinking this water (assuming that this water represented one-half of his normal daily water intake) would accumulate an annual dose commitment of 4.0 mrem. This can be compared with the 170 mrem specified as an annual standard for individuals and population groups in uncontrolled areas.

g. Conclusion

Radioactivity in discharge wastes at INEL does not result in radiation concentrations in excess of the guides for drinking water. Liquid waste discharged through a well results in additional dilution. As long as the water remains below ground, the concentration continues to diminish by the process of radiological decay, continuing dispersion, and some sorption on earth minerals.

Discharge via a seepage pond increases the attenuation of concentration by means of additional mineral sorption, increased allowance for decay, and a wider area of dispersion. While this enhances the quality of percolating water, the accumulation of radionuclides in the earth column below the pond results in a nuisance impact on the environment which ultimately will require the dedication of a small land area to perpetual care.

4. Nonradioactive Liquids Discharged to the Lithosphere[a]

a. Sources of Discharges

These liquids accrue from sewage, water softening and demineralization, cooling, and purge of boiler water.

Sewage effluents, after passing through treatment plants or septic tanks, contain organic residues and chlorine. The treated sewage wastes are discharged to ponds and subsurface irrigation fields. This technique creates no adverse effects and therefore is not discussed in detail. The volumes represent about no more than 2% of the consumptive water use and total between 25 to 50 million gallons/yr from all establishments.

Water treatment wastes are discharged to surface treatment ponds at all plants except at ICPP, where they are discharged to a well together with low-level radioactive wastes. All these wastes contain naturally occurring dissolved solids plus corrosion-inhibiting chemicals.

[a] See Appendix E (Table E-5 and Section 2) for 1975-76 nonradioactive liquid wastes releases, and its environmental impact.

Cooling water is discharged in major quantities at TRA, NRF, and ANL. At TRA, discharge is made routinely to a well. The water is monitored for radioactive contaminants; if any are detected, the stream is diverted to the radioactive waste disposal pond. About 200 million gallons/yr have gone to the well during the past 8 yr. The NRF facilities discharge about 300 million gallons/yr to the land surface. This waste consists of water treatment process waste, boiler blowdown, and liquid wastes from miscellaneous cooling processes. The ANL plants discharge about 50 million gallons/yr to surface ponds.

The waste cooling water from reactor systems contain chromium which is added to inhibit corrosion. The drinking water tolerance for chromium in the chromate condition (Cr^{+6}) of 0.05 ppm (or 0.05 mg/l) has been imposed. This has resulted in either the substitution of phosphate chemicals for chromium or the chemical reduction procedures to change the chromate to the chromite condition (Cr^{+3}).

The mean concentrations of dissolved solids in the liquid wastes at the points of discharge have been approximately equal to that permissible for drinking water, or about 500 ppm. The effects have been studied in detail at only two of the discharge points: TRA and ICPP.

Between 19,000 and 25,000 gallons/yr of waste oils, greases, and solvents are retained and used as a dust palliative on unsurfaced roads at INEL. Some is sold for the same purpose offsite. The impact from this type of waste is therefore inconsequential other than that it might be better reclaimed for lubricating or as fuel[108].

b. Land Commitment and Impact

The use of land for waste discharge via a well is insignificant or inconsequential. Disposal ponds, however, require the commitment of some land area. The TRA waste pond occupies about 1 acre. The NRF drainage ditch occupies about 3 acres. The ANL pond is 1 acre or less. Sewage waste from TRA is discharged to two ponds which occupy about 1/2 acre. The seepage areas at ICPP cover no more than 1/2 acre. The CFA seepage pond occupies about 3/4 acre. The sewage lagoon at NRF covers 14 acres. The sewage treatment plant effluents at TAN are discharged to a seepage area enclosed by a dike which encompasses about 34 acres. In summary, the total area devoted to discharge of nonradioactive liquid wastes is about 55 acres. This acreage is not permanently dedicated, and consequently could be reclaimed. The agricultural use of the land which the disposal ponds occupy could be compromised to some extent by the residual compounds.

c. Water Resource Commitment and Impact

The volume of water processed as sewage waste at INEL is less than 2% of the water pumped for all uses. The sewage waste is not monitored after it is discharged, although some of the water associated with other measurements is, in all probability, contributed to by these discharges. However, chemical wastes from TRA have been studied with respect to the effect on water quality[76].

Between 45 and 50 million gallons/yr of chemically contaminated wastes are discharged to a pond at TRA. This volume originates from four cationic exchangers using sulfuric acid, two anionic exchangers using sodium hydroxide, and four softeners using sodium chloride. About 600 tons of sulfuric acid, 300 tons of sodium hydroxide, and 50 tons of sodium chloride are consumed annually.

A well has been used for disposal of nonradioactive liquid wastes at TRA since 1964. Waste water from the cooling tower composes a major part of this stream. These wastes usually contain an average concentration of about 500 mg/l of dissolved solids, such as calcium and magnesium salts, which normally are found in natural waters. The effects of this discharge on the regional water table are described in connection with those from ICPP.

Chromium compounds have been previously used as a corrosion inhibitor in TRA reactor coolant piping systems. During the early 1970s, the concentration of chromium used in the reactor coolant systems was reduced; and in 1972 the use of chromium was discontinued entirely. A phosphate-based corrosion inhibitor now is being used instead of the chromium. The concentration of phosphate being released to the aquifer is only 10% of the water quality criteria of the State of California (no specific criteria for phosphate exists in Idaho). The concentrations of chromium in the aquifer from previous discharges are shown in Figure III-37[76]. Prior to 1964, nonradioactive liquid wastes were discharged to the pond used for low-level radioactive waste streams. Since then discharges have been made to the well, with only occasional discharges to the pond. Discharge concentrations of Cr^{+6} in these effluents were no more than 2 mg/l. Only minor changes in the distribution pattern over the 5-yr period are indicated. The drinking water criterion for Cr^{+6} is 0.05 mg/l, which is exceeded over a considerable area of the aquifer (perhaps 1 mi^2 or more). There are no supply wells within this area,and the discharge has been discontinued; thus contamination is expected to be dispersed or diluted to a level below the permissible maximum.

Chemical wastes at ICPP are included with the radioactively contaminated effluents and is discharged directly to the aquifer via the disposal well. The nature and quantities of the chemical compositions of the wastes have not been continuously monitored; however, records on quantities of chemicals used and of water volume discharge can be used to calculate a discharge concentration of 520 mg/l of dissolved solids.

The effects can be seen by observing the distribution of chloride and sodium in the aquifer system and the specific conductance of the water. The naturally occurring concentration of chloride at

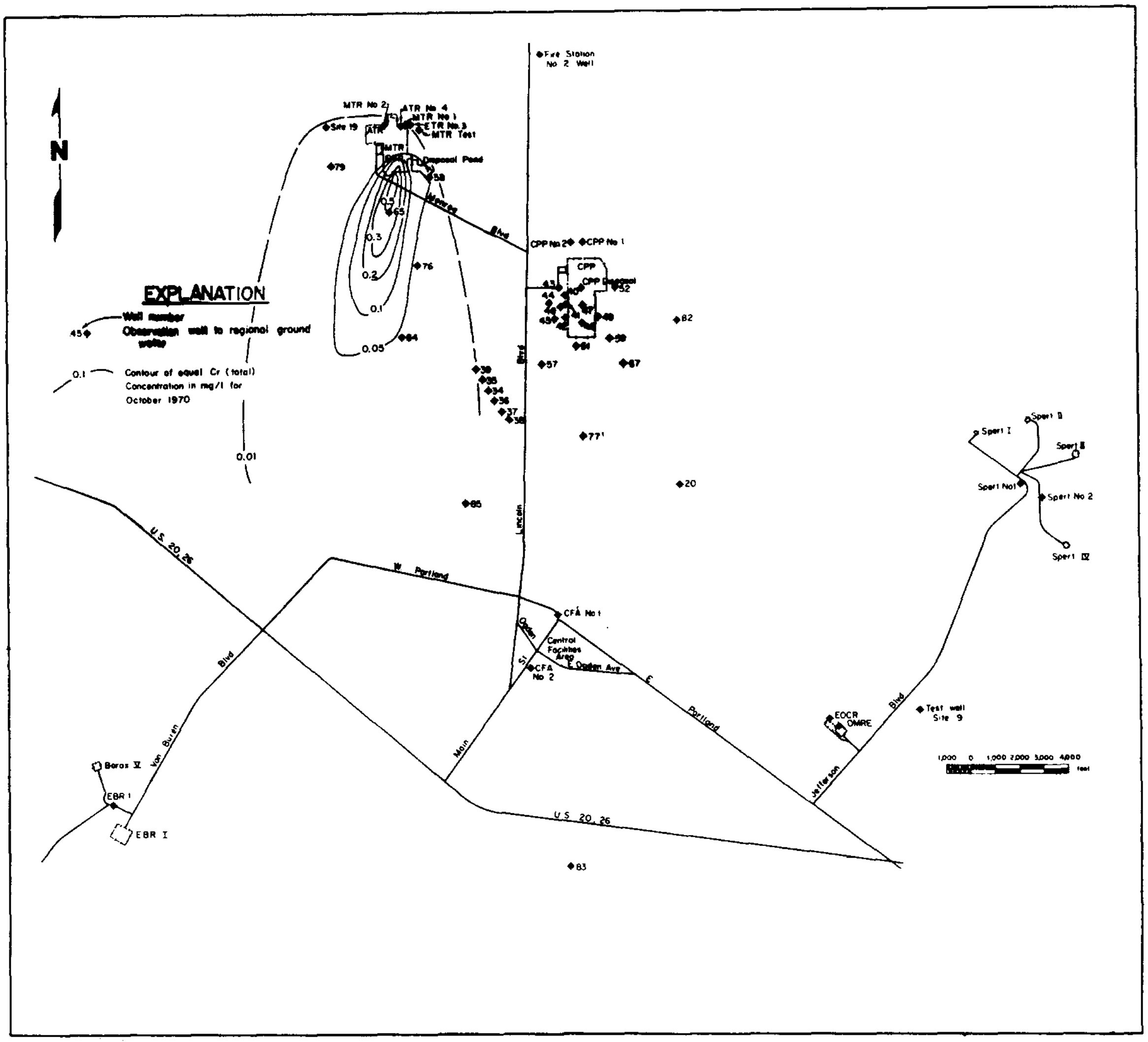

Figure III-37. Sketch of the ICPP-TRA Vicinity Showing Distribution of Waste Chromium in Snake River Plain Aquifer 1970.

the TRA-ICPP area is 9 or 10 mg/l. Any water sample analysis with chloride concentration of more than 15 mg/l has been taken as evidence of waste discharge effect. The first complete analysis was made in 1958 and repeated in 1960 and 1969[76]. Between 1953, when liquid discharge first started, and 1958, the contamination had moved from the ICPP well to the CFA well No. 1, a surface distance of 2.5 miles. This movement indicated a mean velocity of 7 ft/day. Little change in velocity was indicated between 1958 and 1960. Enlargement of the contamination plume and the effect of the TRA discharge became apparent in 1969,as shown in Figure III-38. Dilution of chloride by dispersion is apparent by the fact that the original concentration of 200 mg/l at or near the ICPP discharge well is reduced to 50 to 70 mg/l over a significant area. The permissible concentration of chloride is 250 mg/l[109].

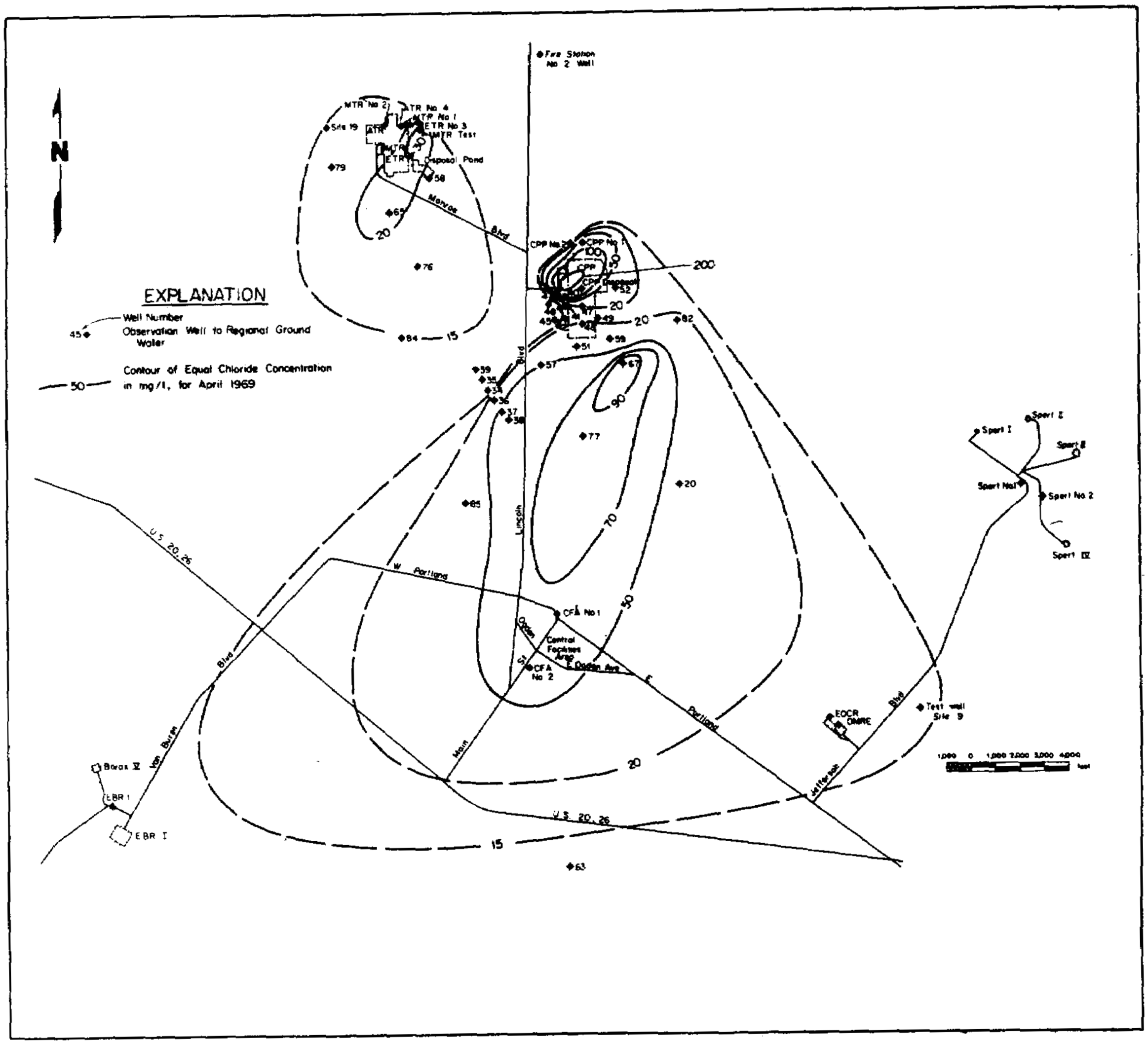

Figure III-38. Sketch of the ICPP-TRA Vicinity Showing Distribution of Waste Chloride in Aquifer Water, 1969.

The natural concentration of sodium is 7 to 9 mg/l. On this basis a lower limit of 10 mg/l is considered as indicative of waste contamination. The distribution pattern is similar to that for chloride; however, the concentrations are lower in relation to the normal two-to-three ratio for sodium to chloride in common salt (sodium chloride).

A plausible explanation is that cationic sodium is retarded by ion-exchange reactions with natural earth minerals. This reaction is also the reason that sodium from the TRA pond is less evident in the groundwater as shown in Figure III-39 which shows the distributions as of 1968[76].

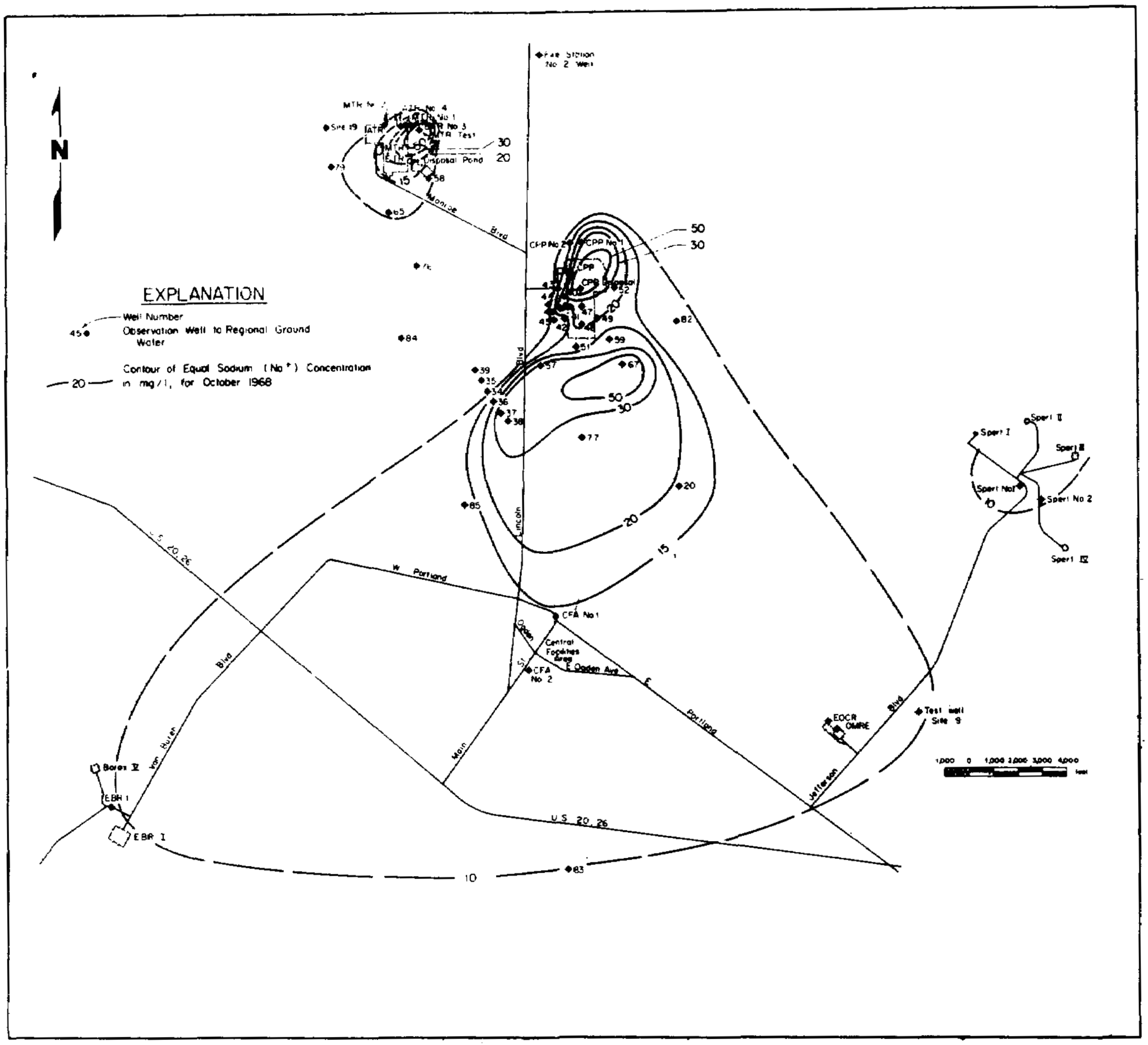

Figure III-39. Sketch of the ICPP-TRA Area Showing Inferred Distribution of Sodium Resulting From Salt Disposal in Aquifer, 1968.

Specific conductance of water results from the combined effect of dissolved solids of all types. The ratio of dissolved solids (mg/l) to specific conductance (mhos/cm) in natural groundwater ranges from about 0.59 to 0.63. Wastes from ICPP and TRA depress the ratio to about 0.57 which, when applied to the 700- to 1,000-mg/l concentrations near the ICPP well, gives a dissolved solids content in the effluent of 400- to 500-mg/l concentration. This concentration is congruent with the previous discharge concentration estimates. Figure III-40 shows conductance isopleths for 1970. The effect of the TRA discharge to ponds is apparent. The 400 to 500 mmhos indicate a dissolved solids concentration of about 250 ppm in comparison with the permissible criterion of 500 ppm[76].

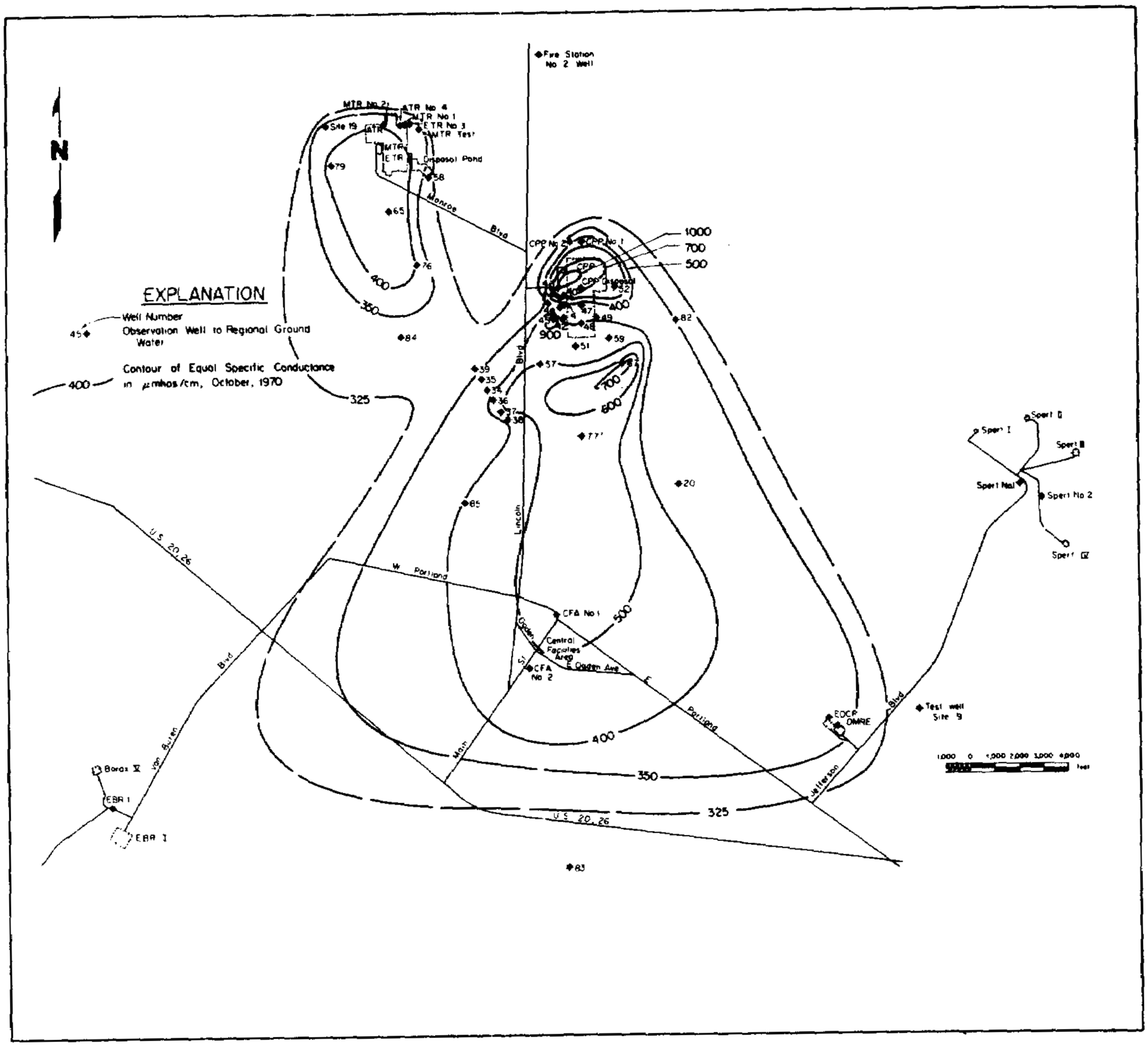

Figure III-40 Specific Conductance Anomalies in Groundwater Resulting from Waste Disposal at ICPP and TRA, 1970.

d. Impact on Biota

When nonradioactive waste water is discharged into wells, the stream does not contact the biosphere until or unless the groundwater is used for irrigation. Disposal ponds do have contact with the biosphere; e.g., they may serve as a water point for small animals. However, the water is not toxic and even the taste may not be affected.

It can be postulated that water might be pumped for irrigation from the aquifer which has become contaminated. Absolute limits to the permissible concentrations of salts in irrigation water are difficult to establish and to apply because of many variable soil and plant relationships. Generally, water containing up to 1,000 mg/l of dissolved solids is suitable for irrigating all types of plants, and 3,000 mg/l is near the maximum for more tolerant crops. On this basis, the chemically contaminated water would be suitable for irrigation at the point of discharge and presents no potential detrimental impact as far as irrigation potential is concerned.

e. Impact on Man

There are no supply wells penetrating the aquifer within the area encompassed by the areal distribution of the chemical contaminants with the exception of the ICPP-CFA-EOCR/OMRE wells. In these cases, the specific conductance indicates a maximum total dissolved solid concentration of about 300 mg/l as compared with a permissible drinking water concentration of 500 mg/l. Also, samples from drinking water supply wells at all INEL facilities are taken monthly and a water culture monitored for e. coli bacteria. There never has been any instance of hazardous biological content of INEL drinking water supplies.

f. Conclusion

The effect of nonradioactive but chemically contaminated liquids can be detected in the groundwater in an area of about 25 square miles. The concentrations of dissolved solids are below Federal and state permissible criteria standards for drinking water with the exception of chromium; this situation, however, does not threaten any existing or planned well. No contamination has been detected beyond the INEL boundary. The presence of chemicals resulting from waste disposal would not impair the use of groundwater for any postulated or hypothetical use for irrigation.

5. Radioactive Solid waste Disposal and Storage[a]

a. Facilities Used for Disposal or Storage

The solid radioactive waste facilities at INEL are the Radioactive Waste Management Complex, SL-1 Burial Ground, ANL Solid Waste Storage Area, and the ICPP Calcined Waste Storage Area (all are described in Section II). Since these facilities have been in operation, no impact to the environment at any location outside the INEL boundaries has been detected. This experience indicates that current management practices ensure that radiation exposures to the public will continue to be well within established guidelines, and that the wastes will remain isolated from the general environment for the foreseeable future.

At the RWMC and SL-1 Burial Ground, fission and activation product wastes are burried directly in the soil below ground level. Wastes containing transuranic and U-233 activity above 10 nanocuries/gram currently are stored above the land surface in fire-resistant and watertight containers. These containers are placed on an asphalt pavement and covered with plywood, plastic, and soil. At the ANL Solid Waste Storage Area and at the ICPP Calcined

[a]See Appendix E, Tables E-3 and E-4, for 1975-76 solid waste disposal/storage data.

Waste Storage Area, radioactive wastes are stored in watertight steel containers and concrete vaults placed below ground level. Table III-20 lists the total amounts of wastes located in each of these areas as of the end of December 1974.

TABLE III-20

TOTAL AMOUNTS OF SOLID RADIOACTIVE WASTES BY AREA 1952-1974

Area	Volume (ft^3)	Curies
RWMC Subsurface Disposal	4,990,000	5,978,000
Transuranic Storage Area	864,000	93,525
SL-1 Burial Ground	81,930	600
ANL Radioactive Scrap and Waste Facility	2,215	9,399,000
ICPP Calcined Waste Storage [a,b]	43,000	53,000,000
Total	5,980,000	68,470,000

[a] Storage

[b] Represents 2.8×10^6 gal of liquid waste

The estimated curie amounts apply at the time of deposition, or in the case of ICPP at the time of calcination. Radioactive decay has reduced the amount of activity.

b. Land Commitment and Impact

The total land commitment associated with these solid radioactive waste management facilities is about 0.03% of the total INEL area. The following individual areas are enclosed within fences and are committed indefinitely:

(1)	RWMC Subsurface Disposal Area	88 acres
(2)	TSA	58 acres
(3)	SL-1 Burial Ground	4 acres
(4)	ANL Radioactive Scrap and Waste Facility	5 acres
(5)	ICPP Calcined Waste Storage Area	3 acres
	Total	158 acres

The construction and operation of these storage and burial locations have entailed excavation and replacement of soil. The RWMC Subsurface

Disposal Area is the only area where excavation is being performed routinely. This activity has continued throughout the operational period and does not contribute to atmospheric dust problems. Earthfill has been removed from borrow pits in adjacent areas. These areas have been graded to conform to existing topography and reseeded with crested wheat grass to hold the soil until native growth returns; however, the area has been compromised to some extent because the remaining soil is shallow.

Fences exclude grazing animals such as antelope and domestic livestock which occasionally approach the area near RWMC. The result of these exclusions might be appraised on the basis that the overall grazing capacity of the Snake River Plain is 15 to 20 acres per animal-unit-month (AUM). This implies that the 158 acres devoted to solid waste management otherwise would support about six cows for one month or one cow for six months. One cow requires about as much grazing area as four or five antelope.

c. Impact on Air and Water

Wastes are buried directly in the soil at RWMC and SL-1 Burial Ground. If water percolates through these wastes, there is a potential for leaching of radioactivity and moving it toward the aquifer. Current practices at RWMC are designed to minimize this possibility. Grading and drainage of surface water reduces percolation from surface puddles. Presently a 2-ft layer of soil is left between the wastes and underlying basalt rock. The sorptive capacity of this soil for waste contaminants plus that in the rock interstices, provide reasonable assurance that any leached contaminant will not reach the regional aquifer 585 ft below, or the nearest stock watering well 10 mi away, or domestic water supply 55 mi away.

On two occasions, 1962 and 1969, unusually rapid snow melting and rain caused local flooding at RWMC in which water came in contact with waste in partially filled pits and trenches. Low concentrations of contaminants in the water resulted, (e.g., 10^{-5} μCi/ml beta activity and 10^{-7} μCi/ml alpha activity). Soil and water samples subsequently were taken at various depths and locations adjacent to the repositories; analysis revealed that the contaminants were sorbed within inches of the interface between the soil and waste, with no evidence that the contaminants were migrating to the underlying aquifer[104].

An investigation at greater depths was conducted in 1970-1972 which involved four wells penetrating 40 ft below the water table at locations outside the Subsurface Disposal Area. Six wells were drilled to intermediate depths of 250 ft at locations within the area. These wells defined the stratigraphy and lithology of the area. In addition to the surface soils in which the waste is buried, two unconsolidated soillike strata averaging 12 and 13 ft thick were encountered at depths of 110 and 240 ft. Several thinner, and probably discontinuous, strata were found in the 500- to 600-ft depth interval. The groundwater gradient, at the time it was encountered, was toward the INEL interior or toward the northeast and opposite to the generalized gradient shown in Figure II-63. A very small quantity of water was encountered at the 215-ft level. One of the intermediate depth wells was retained to monitor this zone, while the others were plugged[110].

Radiochemical analyses of samples taken in subsurface sediment beds and groundwater have shown instances of detectable contamination[110]. Of the 58 sedimentary samples taken, 27 showed radioactivity at levels detectable only by the most sensitive radiochemical methods. Because of the techniques inherent in the drilling operations, such levels could well have arisen through contamination of the drilling cores from surface sources.

In 1975 two additional wells were drilled inside RWMC near the wells where earlier samples showed statistically positive quantities of waste nuclides. The object of these drillings was to use improved coring techniques and improved anti-contamination measures and sample the sedimentary layers at the 110- and 240-ft level for radionuclides. Samples taken from these sedimentary layers from this drilling program[110a] showed no waste nuclide radioactivity using analytical procedures of high sensitivities. Because of the extensive measures taken in this study to minimize extraneous contamination of cores, high confidence is placed in the results. The absence of waste nuclide radioactivity in samples analyzed in this program suggests that sample contamination may have been a factor in the 1970-72 study.

This core drilling program will continue through October 1977. Additional core drilling for special sampling will be performed immediately beneath some of the buried wastes with periodic reports to be issued.

A continuing environmental monitoring program is in effect at RWMC for surface migration of radionuclides[110b]. This program is summarized in section II.C.12. During 1974 air samples around RWMC indicated no excessive airborne contamination levels; all gross alpha results were less than 1×10^{-13} μCi/cc, which is significantly less than the most restrictive allowable plutonium-239 air activity of 2×10^{-12} μCi/cc for a restricted area. The majority of measured alpha activities in air samples ranged between 1×10^{-14} and 5×10^{-14} μCi/cc.

Surface water samples from rainfall or snow melting were routinely collected. Only two samples indicated any radionuclide in excess of background levels. The two positive results had low-level cesium-137 activities of $8.1 \pm 2.3 \times 10^{-7}$ μCi/ml and $6.8 \pm 3.2 \times 10^{-7}$ μCi/ml, respectively. These measured values are far below the ERDAM-0524 limits of 4×10^{-4} μCi/ml for restricted areas.

Surface soil samples show statistically significant plutonium content for soils collected within the Subsurface Disposal Area (SDA). Average plutonium activity is five disintegrations per minute per gram of surface soil (d/m/g). Local background radiation due to weapons fallout is in the range of 0.1 to 0.3 d/m/g in surface soils. The contamination levels are in the interior of the fenced SDA and drop off sharply with distance, suggesting that winds have not seriously mobilized the contamination. This monitoring program is continuing.

A large amount of radioactivity is stored at the ANL Solid Waste Storage Facility. A major part of this activity is contributed by activation products which have a relatively short half-life and low biological significance (e.g., cobalt-60 - 5.3 yr). The material is contained in cans within sealed steel liners. An empty steel liner is positioned in the storage facility and used for corrosion studies to verify the integrity of the enclosure over long periods of time. A metallurgical analysis of this liner after five years indicated essentially no detectable corrosion. These studies will continue for the life of the facility.

Soil samples have been taken inside and outside of the perimeter fence around the solid waste storage facility. Soil samples have been taken inside and outside the perimeter fence around the Solid Waste Stroage Facility. These samples include both surface and core samples to depths of 10 ft within the fenced area. The core samples have not indicated any radioactivity above background. Some isolated amounts of cesium-137 (2-18 pCi/gm) above world fallout levels (1 pCi/gm) have been detected inside the fence from surface samples, which are attributed to the facility operations. There is no evidence of environmental contamination outside the fence.

The ICPP waste calcination storage area is part of the WCF. The product is stored in stainless steel tanks housed in reinforced concrete vaults. Heat and corrosion data have been collected for the purpose of indicating a projected integrity of at least 500 years. The effects of various catastrophies such as earthquakes and floods have been considered in the design. While this facility does not necessarily meet all criteria for ultimate waste disposal, it incorporates all realistically available engineered safeguards. The waste is considered to be retrievable for transfer, additional processing, and ultimate disposal. In the meantime, the environmental impact is minimal.

d. Impact on Biota

As discussed above, the loss of grazing or wildlife habitat as a consequence of waste management facilities has a small effect on the big game in the area. The rodent populations could be deprived temporarily of habitat as waste operations progressed, but will not be deprived permanently of access to the areas. Some small rodent-type animals could burrow down to the buried wastes and ingest or spread contamination to the surface. Only minor amounts of activity would be involved, and the gross consequence would be negligible. Predatory animals conceivably could consume contaminated rodents, but the individual effect would be very small. Radioecology studies currently under way at RWMC are designed to provide information concerning the long-term impact of these operations on the area's biota. In this study a sampling grid of 34 locations has been laid out and permanently marked near the Subsurface Disposal Area. At each of these sampling locations soil samples are collected and analyzed. In addition, at each sampling location up to 11 deer mice (peromyscus maniculatus) have been collected and dissected and the tissues weighed and frozen for later analysis. Preliminary results from this study indicate the concentrations of plutonium-238, -239, and americium-241 in the deer mice tissues were low, with many of the samples near or below the minimum detection limit for the isotopes. This study is continuing, and the collected data will be summarized and published in reports which will be available to the public upon request.

e. Impact on Man

A potential for direct radiation exposures to employees exists during handling and storage of wastes at the solid waste management facilities; however, these areas are monitored and controlled to preclude unauthorized entrances and to ensure that no unnecessary exposures to personnel occur. The disposed wastes are covered with sufficient soil to reduce radiation levels to below 1 mR/hr at 1-m height above the ground surface. Consequently, the potential for direct radiation exposure to the public is minimized and localized within the controlled area. Monitoring and maintenance will continue for the foreseeable future to provide additional details on environmental impact and to provide a basis for evaluation of future human uses of these areas.

The fence around the solid radioactive waste management areas precludes grazing on possibly contaminated land. Hunting is not allowed on INEL; and the small rodents, and the predatory and game animals at INEL do not enter directly into the human food chain. The desert vegetation is not harvested or used by humans, further precluding the entrance of contamination into this food chain. Resuspension of surficial contamination represents a possibly important route to man for the alpha-emitting radionuclides. Snowcover greatly reduces the chance of any resuspension, generally from late fall to early spring of each year. Measurements by alpha spectrometry on samples of air dust have shown plutonium-238 and plutonium-239 concentrations at CFA during the most probable times for resuspension to be less than 10^{-17} $\mu Ci/m^3$. Continuous exposure to this concentration for six months would result in inhalation of no more than 0.036 pCi of each isotope and a total lung dose of less than 0.05 mrem. The longest credible exposure period for a member of the public is a brief stopover at the rest station at the Lost River bridge on U. S. Highway 20, and the potential dose is correspondingly lower (less than 0.002 mrem).

As indicated in Section II.A.9, efforts are now underway to retrieve a portion of the buried transuranic wastes at the Subsurface Disposal Area of RWMC in order to investigate the feasibility, costs, and impacts of large-scale exhumation of this kind of waste. The environmental implications of this program are minimized by the use of an air support building. The building is positioned over the retrieval site and is used to provide favorable working conditions during inclement weather. An additional benefit is containment for any potential source of loose contamination. The building has controlled ventilation; and Health Physics monitoring equipment provides continuous data during all retrieval operations. The disposed 55-gallon drums are uncovered, retrieved, and repackaged in 83-gallon drums. When all drums at the work site have been retrieved, the excavated area is restored, the air support building is moved to another location, and the sequence is repeated. The repackaged drums are transported to TSA for storage. All sampling and monitoring to date indicate the operation is proceeding without any adverse impact upon the environment.

RWMC and the SL-1 Burial Ground will be maintained as controlled access areas for the foreseeable future in order to preclude direct radiation exposures and the spread of contamination. Final cover and protection methods have been postulated which will minimize the environmental impact resulting from the long-term commitment of this land area.

f. The INEL burial grounds controversy

A number of commenters on the draft of this statement, including Idaho Governor Andrus, called attention to lack of discussion of statements made by the Atomic Energy Commission in 1970 to Idaho officials concerning removal of transuranic wastes from above the Snake Plain Aquifer at the INEL. These wastes were brought to INEL from the Rocky Flats Plant in Golden, Colorado, and routinely buried in trenches or pits. This plant produces plutonium components for the nuclear weapons program and generated the waste as part of the routine operations. However, as a result of a fire at the Rocky Flats Plant in 1969 and the resultant cleanup operations a large volume of solid waste contaminated with plutonium, which could not economically be decontaminated, was brought to INEL. Publicity stemming from the fire caused questions to be raised by Idaho officials regarding the safety of burying the Rocky Flats waste at Idaho. The concerns centered on the relatively long half-life of plutonium-239 and its toxicity.

In response to a request from U.S. Senator Frank Church, the Bureau of Radiological Health (BRH) of the U.S. Public Health Service made an onsite review of INEL radioactive waste management practices. The findings of the BRH were summarized as follows in the letter of transmittal in February 1970 to Senator Church from the Assistant Surgeon General:

> "It is our judgment that the land burial techniques currently in use meet the radiation safety criteria of the Federal Radiation Council for protection of the public. Extensive environmental radioactivity data are available for the site which show that no health and safety problems have occurred as a result of the burial of solid radioactive wastes. This experience also indicates that it is not likely the radioactivity will migrate from the burial grounds in the future if current procedures are continued. Because of the potential long-term effects, additional safety measures, consistent with a conservative approach regarding radioactivity, are recommended in the staff study."

These recommendations, which have been implemented at INEL, were as follows:

(1) Each trench and pit should be covered and maintained with a minimum of three feet of soil above the ground level.

(2) A minimum of two feet of alluvial soild should be required beneath all buried wastes.

(3) Flood control measures should be taken to prevent any accumulation of water in the trenches and pits.

(4) Test holes should be drilled in the vicinity of the burial site to provide detailed information on the lithology and character of the alluvial deposits of underlying basalt.

(5) Plutonium and americium waste should be segregated in special pits.

(6) Monitoring should be intensified to provide a positive indication that radioactive material has not migrated from the waste burial ground.

(7) Plutonium and americium waste should be accessible for removal from the burial ground should it be detected in monitoring holes.

The reassurances as to the absence of any near-term problem did not fully satisfy the concern of Idaho officials as to the long-term safety of the aquifer underlying the INEL. AEC Chairman Seaborg indicated to Senator Church on June 9, 1970, that:

> "In FY [Fiscal Year] 1972 AEC will seek authority to establish a demonstration radioactive waste repository in salt which will store both high-level wastes from fuel reprocessing plants and low-level alpha particle emitting wastes (alpha wastes) such as the Pu-contaminated wastes from the Rocky Flats Plant. When the salt mine repository is fully operative, AEC plans to store not only currently generated alpha wastes but also to excavate, process and ship such wastes which are being temporarily stored at NRTS. A number of years will be required to complete the transfer of such wastes from NRTS which we hope to start within the decade."

The Fiscal Year 1972 authorization request referred to by Dr. Seaborg was for a repository in salt with a tentative site selection at Lyons, Kansas, subject to the satisfactory completion of certain additional tests and studies. The projected availability of this Lyons repository was 1976, so that the beginning of waste transfer from Idaho before the end of the decade seemed a reasonable hope. However, site-specific safety questions arose at the Lyons site and when it appeared that they might not be satisfactorily answered in a reasonable time, that project was abandoned in mid-1972 and a search for alternative locations begun.

In the ERDA budget submitted to Congress early in 1975, increased funding was requested for core drilling to evaluate a bedded salt area in southeastern New Mexico, identifying the work with the need to provide a repository for the permanent disposal of ERDA-generated transuranium waste, especially the backlog of Rocky Flats waste at Idaho. Site evaluations in this southeastern New Mexico area have provided confidence that this location will be suitable for a repository and current plans call for completion of construction of this facility by 1984. The repository should provide the highest possible degree of safety and isolation of these wastes. The facility will be the subject of a separate environmental impact statement.

In addition to the availability of a permanent disposal repository, another major problem is the authorization and funding of the waste removal. An operation of this magnitude will very probably require specific appropriations from the Congress. This will be especially true for any proposal to remove the significant portion of the transuranium waste which was buried in pits and trenches before adoption of the present more readily retrievable storage system in 1970.

Exhumation of buried wastes is not without risk, as pointed out by the National Academy of Sciences in a recent report [119] which recommended a close examination of the benefits of any such exhumation and of its alternatives. Such comparisons are consistent with the provisions of the National Environmental Policy Act. ERDA is now preparing a report on the technical alternatives for long-term management of the transuranic wastes at INEL. This report is scheduled to be released for public review and comment in late 1977 and will include, for example, a discussion of the findings of the test exhumations conducted over the past few years on small volumes of buried transuranic wastes of different ages and kinds of packaging.

The next step will be preparation of an environmental impact statement on the long-term management alternatives for transuranic waste. This statement will also be made available for public review, and in final form will provide the environmental input into future decisions on the long-term management of the wastes.

g. Conclusion

Solid waste management involves an indefinite commitment of 158 acres of desert grazing land with a grazing capacity of about 6 AUMs per year and an equivalent habitat for small rodent-type animals.

There is no evidence that waste nuclides have thus far moved below the waste burial areas to an extent that would compromise in any way the quality of the groundwater.

Work is in progress to evaluate the environmental impact of alternatives for long-term management of the solid wastes at INEL.

6. Nonradioactive Solid Waste Disposal[a]

a. Facilities Used for Disposal

Since 1970 most nonradioactive solid waste has been disposed of in a sanitary landfill located in a gravel pit at CFA. Small quantities of construction debris are disposed of at the TAN solid waste management site. This waste is generated at an average rate of 20 tons per week. During 1974 industrial waste was contributed, by volume, at the INEL areas in the following proportions:

(1) ICPP - 12%

(2) TRA - 15%

(3) ARA-SPERT - 5%

(4) CFA - 15%

(5) NRF - 30%

(6) ANL - 13%

(7) TAN - 10%

The waste entering the CFA sanitary landfill is composed of approximately 90% highly combustible waste such as paper, cardboard, wood, rags, etc., and 10% garbage such as animal and vegetable wastes, primarily from cafeterias. In addition, construction and demolition wastes are estimated at an average of 20 tons per month. The waste material is monitored in the various plant areas and stored in 4- to 8-yd^3 metal Dempster dumpster containers. These containers are marked to distinguish clearly between nonradioactive and radioactive storage destination. The containers used to store the cafeteria wastes have tight fitting lids to restrict access of disease vectors to the waste material.

Combustible wastes are collected with a 30-yd^3 capacity Dempster dumpster, on a frequency compatible with waste generation rates. The cafeteria wastes are collected using a specially designed truck that hauls the storage containers to and from the landfill. The collection frequency of this waste is determined by weather and sanitary considerations, as well as by generation rates.

[a] See Appendix E, Table E-5 for 1975-76 nonradiological solid waste data.

The waste is delivered, spread, and compacted in a thin layer (about 40% of the original volume) by heavy equipment. It is covered daily with a 6-in. layer of earth barrowed from within the working area.

b. Land Commitment and Impact

The pit in which the landfill is being developed has served as a source of gravel since the area was used as a gun testing range during the 1940s. The pit no longer serves its original purpose. It occupies an area of about 70 acres and has been excavated to a depth of 15 ft. The landfill occupies about one-third of the pit area. Filling that pit with waste followed by an earth cover will have the effect of restoring the area to a condition resembling the original land form.

c. Water Commitment and Impact

The regional water table is about 450 ft below the land surface. The gravelly regolith is about 30 ft thick, but the thickness varies as a result of the undulating surface of the underlying basalt. Runoff or floodwater does not accumulate in the pit, and any rain or snowfall quickly seeps away. The waste layers disrupt the permeability of the fill, and the limited rainfall does not penetrate or percolate through. Consequently, there is no threat to the groundwater as a result of this operation. Even if hypothetical worst-possible situations are postulated, it is inconceivable that combustible wastes would compromise the groundwater 450 ft below.

d. Conclusion

The disposal of nonradioactive solid waste by means of a landfill in an abandoned gravel pit does not have any identified adverse impact on biota, man, or the environment.

7. Waste Heat Discharge

Heat is discharged from several sources: space heat, process heat, electrical consumption, reactors, and vehicles. These sources are described below.

a. Dissipation of Heat from Space Heating and Processing Equipment

Heat is dissipated to the atmosphere from all buildings which house people, goods, or process equipment. Most of the heat is generated from the combustion of No. 2 and No. 5 fuel oil. Some also is rejected from the use of electrical equipment. Heat generated in operational processes and for use in process equipment is, in most cases, also dissipated to the atmosphere. Table III-21 gives the yearly average dissipation from these sources.

TABLE III-21

HEAT DISSIPATED TO ATMOSPHERE FROM SPACE AND PROCESS HEATING AND ELECTRICAL SOURCES

Source	Quantity	Heat to Atmosphere (Btu)[a]
Diesel fuel	1,500,000 gal	2.0×10^{11}
Kerosene	2,250,000 gal	3.4×10^{10}
No. 2 fuel oil	2,500,000 gal	3.5×10^{11}
Nos. 5-6 fuel oil	10,000,000 gal	1.4×10^{12}
Electricity	183,000,000 kWh	6.24×10^{11}
Total for INEL		2.6×10^{12}

[a] A Btu is approximately equal to 252 calories.

b. Dissipation of Heat from Nuclear Reactors

Heat from reactor operations is transferred to the atmosphere by evaporation type heat exchangers, air-cooled condensers, and spray ponds. The anticipated rate for these sources is given in Table III-22.

TABLE III-22

HEAT DISSIPATION TO ATMOSPHERE FROM REACTOR OPERATIONS

Reactor	Area	Means	Estimated Total (Btu/yr)
EBR-II	ANL-W	One cooling tower	9.3×10^{11}
ETR	TRA	One cooling tower	3.9×10^{11}
ATR	TRA	One cooling tower	4.5×10^{12}
	NRF	Cooling towers and spray ponds	1.6×10^{13}[a]
LOFT	TAN	Air-cooled condenser	4.1×10^{11}
PBF	SPERT	Cooling tower	1.0×10^{11}
Total for INEL			2.2×10^{13}

[a] Estimated

c. Dissipation of Heat from Vehicles

INEL is a remote area with facilities dispersed widely over the 894 mi^2. Considerable vehicle activity is associated with the operations. Approximately 700,000 gallons of gasoline and 1 million gallons of diesel fuel are expended in an average year.

The heat from vehicles is dispersed to the atmosphere over a wide area involving the roadways between INEL, Idaho Falls, Arco, and Pocatello, as well as the intralaboratory areas. The amount of heat released from this source is approximately 2×10^{11} Btu/yr.

Table III-23 is a summary of the total estimated amount of heat discharged to the atmosphere each year. The total of 2.5×10^{13} Btu can be put into perspective by comparing it with the thermal energy received from the sun at INEL. Using local climatological data[60], it is estimated that this is 1.7×10^{16} Btu. The INEL contribution is 0.15% of the natural radiant heat, which is inconsequential.

d. Dissipation of Heat to the Lithosphere

This results from the discharge of waste water to the groundwater system. Heat emanating from disposal ponds is utilized in effecting evaporation or is dissipated to the atmosphere. The water from ICPP is discharged directly to the aquifer via the well discussed in previous sections. The temperature of waste water varies between 65 and 75°F (19 and 21°C, respectively). Assuming a mean discharge of 3.0×10^9

TABLE III-23

HEAT DISCHARGE TO INEL ATMOSPHERE

Source	Discharge (Btu/yr)
Space and process heat	2.0×10^{12}
Electrical conversion to waste heat	6.2×10^{11}
Reactor operations	2.2×10^{13}[a]
Vehicles	1.6×10^{11}
Total	2.5×10^{13}

[a] Estimated

gallons/yr, the thermal discharge would be about 4×10^{10} Btu. The temperature of the groundwater is about 53.5°F (12°C). The effect of the discharge is illustrated by Figure III-41, which shows temperature isopleths for the year 1969[76]. The effect is not distinguishable beyond a distance of 1.7 miles down gradient from the disposal well. The conclusion then is that heat discharges to the lithosphere have not caused widespread temperature changes in the aquifer.

A heat balance has been calculated on the basis of the discharge between 1952 and 1967 and the conductance of the lithosphere[76]. This indicates, assuming the same rate of discharge, that the heat effects will continue to be minor as the conductance is equal to the input and that a state of equilibrium probably has been achieved.

e. Conclusion

The impact of heat dissipation in the atmosphere is inconsequential in comparison with that from natural sources. Discharge of heated liquid waste to the regional aquifer is inconsequential, as the conductance capacity of the lithosphere quickly compensates for the input.

8. Maximum Health Effects from Radioactive Waste Discharges

In the preceding sections the radiation dose to man from INEL releases has been quantified. However, the effect these very low radiation doses has on man is more difficult to determine. In the reports, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation" (The BEIR Report)[111] and "Ionizing Radiation: Levels and Effects"[112], attempts have been made to relate radiation dose to the population to potential health effects. The types of health effects generally considered are cancer deaths, cancer cases, general ill health, and genetic damage.

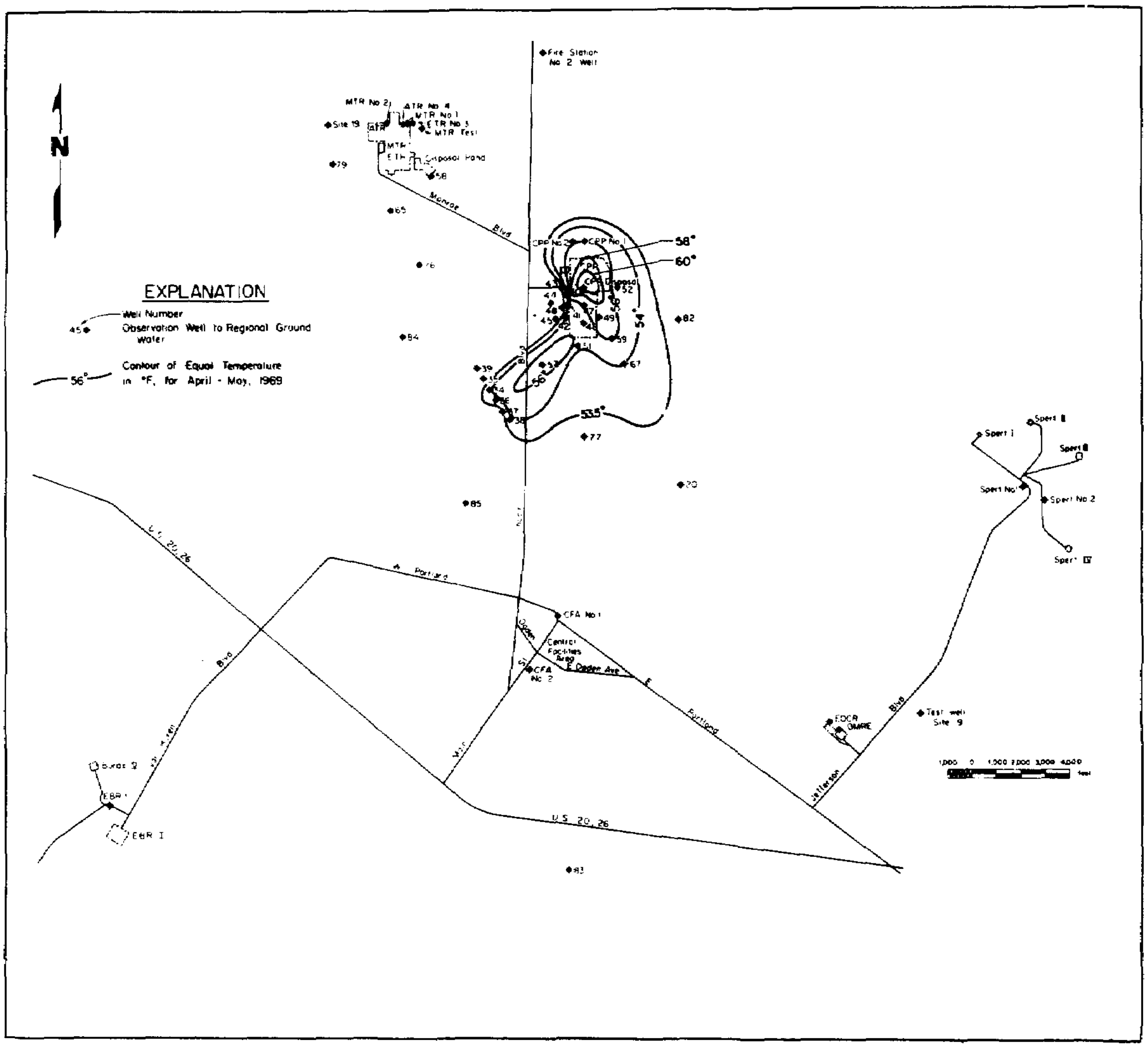

Figure III-41 The ICPP-TRA Vicinity Distribution of Waste Heat in Snake River Plain Aquifer Water, 1969.

Both reports discuss the difficulties in arriving at dose health effect relationships because of the very low number of health effects that might occur at the low doses of radiation being considered. Because of the lack of data at the very low actual dose rates (usually less than 10^{-3} rem/hr) and low total doses, health effect assumptions are extrapolated from data from high dose radiation exposures delivered at very high dose rates (many rem/hr). It is assumed that the dose effect relationship is linear, that it is independent of dose rate, and that there is no threshold dose below which effects will not be produced; use of these assumptions overestimates the expected number of health effects. Further, it is assumed that the equal population doses (the sum of the doses received by all members of a population group) produce equal effects; that is, that a small dose delivered to a large population (e.g., 0.001 rem to each of 1 million individuals) has the same effect as a large dose received by a smaller group (e.g., 10 rem to each of 100 individuals).

For the analysis of the maximum potential number of health effects which might occur as a result of the radiation doses resulting from effluent releases, the conversion factors relating population dose to maximum number of health effects from the BEIR Report as summarized by EPA[113] were used. These values are given in Table III-24.

TABLE III-24

CONVERSION FACTORS RELATING POPULATION DOSE TO MAXIMUM NUMBER OF HEALTH EFFECTS

Tissue at Risk	Conversion Factors for Mortality
Total Body	200 cancer deaths/10^6 man-rem
Lung	50 cancer deaths/10^6 man-rem
Thyroid[a]	5 cancer deaths/10^6 man-rem

Tissue at Risk	Conversion Factors for Incidence
Total Body	400 cancer cases/10^6 man-rem
Thyroid < 1 year old	150 cancer cases/10^6 man-rem
1-19 years old	35 cancer cases/10^6 man-rem
20 years old	5 cancer cases/10^6 man-rem
Weighted Mean[a]	20 cancer cases/10^6 man-rem
Genetic Damage	300 effects/10^6 man-rem

[a] Weighted for an assumed population age distribution given by EPA in Reference 113.

The maximum numbers of health effects were computed using the conversion factors and maximum potential population doses given in Table III-24 which could result from the radioactivity released from the various facilities. The whole body population dose includes the contributions from airborne noble gases, tritium, and particulates (Table III-3) and the external radiation dose commitment from deposition of radioactive particulates released during 1974. The gonadal doses are presumed equal to the whole body doses in the computation of maximum genetic damage. The population thyroid doses presume that all individuals consume 80 kg (176 lb) of meat from animals which are in equilibrium with the iodine-129 levels in their local environment. The population lung doses were computed using the particulate isotope release rates for 1974 and the dispersion map shown in Appendix D. The lung dose was averaged over the entire lung mass in accord with ICRP recommendations. The whole body doses were added to the lung doses from inhaled particulates and the thyroid doses from iodine inhalation and ingestion to obtain the organ population doses shown in Table III-25.

TABLE III-25

ESTIMATES OF VARIOUS HEALTH EFFECTS WITHIN A 50-MILE RADIUS FOR 1974 OFFSITE POPULATION DOSES

Tissue at Risk	Population Dose (man-rem)	Maximum Number of Cancer Deaths[a]
Total Body	7.7	1.5×10^{-3}
Lung	8.5	4.3×10^{-4}
Thyroid	43	2.2×10^{-4}
Tissue at Risk	**Population Dose (man-rem)**	**Maximum Incidence[a]**
Total Body	7.7	3.1×10^{-3} cancer cases
Thyroid	43	8.6×10^{-4} cancer cases
Genetic Material	7.7	2.3×10^{-2} genetic effects

[a] Maximum numbers of effects through all future years for the offsite population doses due to operational releases in 1974.

The maximum whole body population dose due to INEL operations, 2.0 man-rem, may be compared with those from natural background and other sources. The annual 50-mi radius population whole body dose from the 150 mrem/hr natural background radiation is about 10,500 man-rem (and may vary by ∿1,000 man-rem from year to year). In addition to the natural background radiation, the average individual in the United States receives about 73 mrem/yr from manmade sources, principally from medical and dental diagnostic and therapeutic procedures[111]. If the local population is average in this respect, an additional 50-mi radius whole body population dose of 5,000 man-rem would have been received in 1974 from such sources. The contribution from 1974 waste management operations is only 0.02% of the total population dose and cannot be considered a significant addition.

The maximum numbers of health effects are shown in Table III-25. All the computed maximum incidences are fractions much less than one and it may be concluded that there will be no health effects resulting from radioactivity releases from site waste management operations in 1974.

9. Environmental Dose Commitment

The EPA has developed a concept called the "environmental dose commitment" to assess the total impact of a nuclear facility on the environment. "The concept encompasses the total projected radiation dose to populations committed by the irreversible release of long-lived radionuclides to the environment and forms a basis for estimating the total potential consequences on public health of such environmental release"[113]. As stated by EPA, "Because of the difficulty of making projections of radionuclide transport on the basis of present knowledge, these potential consequences have been calculated only for the first one hundred-year period following release." The particular radionuclides considered by EPA were tritium, krypton-85, iodine-129, and the actinides.

The environmental dose commitment from INEL waste management operations is small because of the small quantities of radionuclides released to the environment. An estimate of the INEL environmental dose commitment can be calculated by comparing the releases used by EPA[113] and the INEL releases. For the estimations, all assumptions stated by EPA are adopted and the resulting health effects for the INEL waste management operations for several postualted time periods are calculated. Operating periods and emission rates assumed were:

(a) ICPP and present reactor facilities operate through 1980 with emission rates equal to the average of those observed during the 1970 through 1974 operating period

(b) ICPP and present reactor facilities operate through 2000 with emission rates equal to the average of those observed during the 1970 through 1974 operating period

(c) ICPP and present reactor facilities operate through 2020 with emission rates equal to the average of those observed during the 1970 through 1974 operating period.

The emission rates assumed for all three cases are believed high because process improvements and effluent reduction programs are being developed and adopted continually. The environmental dose commitment was calculated for the four radionuclides considered in the EPA study. Exposures were calculated for a U.S. population increasing from 200 million in 1970 to a constant 400 million in the year 2030 and beyond. The earth's population was taken as 3.5 billion in 1970 with a growth rate of 1.9%/yr.

The quantities of radionuclides potentially released by the nuclear power industry through 2020 were calculated by summing the 5-yr inventory quantities and multiplying by the EPA assumed release fraction as shown in Table III-26.

The health effects calculated to result from this release from the nuclear power industry for the period 1970 to 2020 and for the following 100 years as given by EPA are shown in Table III-27.

The quantities of these radionuclides released by the INEL waste management operations under the three postulated operating periods are given in Table III-28.

For the releases of radionuclides given in Table III-28, the environmental dose commitments in maximum number of health effects

TABLE III-26

POTENTIAL RADIONUCLIDE RELEASES FROM NUCLEAR POWER INDUSTRY

Radionuclide	Total Quantity Produced to 2020 (Ci)	Assumed Release Fraction	Calculated Quantity Released (Ci)
Tritium	1.1×10^{9}	1	1.1×10^{9}
^{85}Kr	1.4×10^{10}	1	1.4×10^{10}
^{129}I	5.5×10^{4}	0.1	5.5×10^{3}
^{239}Pu	1.0×10^{9}	10^{-6}	1.0×10^{3}

TABLE III-27

POTENTIAL HEALTH EFFECTS ON THE EARTH'S POPULATION FROM NUCLEAR POWER INDUSTRY AS STATED BY EPA

Radionuclide	Calculated Curies Released	Total Health Effect	Severity
Tritium	1.1×10^{9}	2,800	2/3 Fatal
^{85}Kr	1.4×10^{10}	6,900	2/3 Fatal
^{129}I	5.5×10^{3}	250	1/4 Fatal
^{239}Pu	1.0×10^{3}	24,000	All Fatal

TABLE III-28

ESTIMATED RADIONUCLIDE RELEASE FROM THE INEL WASTE MANAGEMENT OPERATIONS (curies)

	Postulated Operating Period		
Radionuclide	1974-1980	1974-2000	1974-2020
Tritium	2.1×10^{4}	8.0×10^{4}	1.4×10^{5}
^{85}Kr	8.0×10^{5}	3.1×10^{6}	5.5×10^{6}
^{129}I	7.0×10^{-1}	2.7	4.7
^{239}Pu	7.0×10^{-3}	3.0×10^{-2}	5.0×10^{-2}

are given in Table III-29 for each postulated operating period. The calculation is made by taking the ratio of the releases used by EPA and the estimated releases from the INEL waste management operations and applying the resulting ratio to the health effects as calculated by EPA. This approach accepts all assumptions and calculatory methods used by EPA[113].

TABLE III-29

ESTIMATES OF POTENTIAL HEALTH EFFECTS ON THE EARTH'S POPULATION FROM THE INEL WASTE MANAGEMENT OPERATIONS

	Postulated Operating Period		
Radionuclide	1974-1980	1974-2000	1974-2020
Tritium (2/3 Fatal)	0.05	0.2	0.4
^{85}Kr (2/3 Fatal)	0.4	1.5	2.7
^{129}I (1/4 Fatal)	0.03	0.1	0.2
^{239}Pu (All Fatal)	0.2	0.7	1.2
Severity			
Total Morbidity	1	1	1
Total Mortality	1	2	3

The significance of these values is not known. Although the dose rate is extremely low, the population exposed is taken to be very large. The uncertainties involved in using health effects data from high dose and high dose rate exposures to estimate the effects for extremely low dose rates were reviewed earlier.

C. ENVIRONMENTAL IMPACT -- DUE TO ABNORMAL CONDITIONS

Abnormal or accident conditions caused by malfunctioning equipment, process mistakes, natural phenomena, or sabotage can be postulated for activities carried out at INEL for both nonradioactive and radioactive wastes. Since there are several plants, waste systems, and postulated initiating events, waste streams were examined categorically to identify the general system and the corresponding abnormality which would result in the maximum environmental impact. The accidents analyzed, while not detailed relative to the type of initiating event, represent potential consequence of sabotage directed at waste management operations. For example, tank leaks, pipe leaks, or surface spills might be the result of sabotage. Onsite transportation accidents are another example that might result from less sophisticated sabotage. The consequences or mitigating considerations of each of the general system accidents are discussed separately below.

1. Radioactive Airborne Waste Incidents

The maximum abnormality with an airborne waste system typically would be a failure of a HEPA filter. HEPA filters, used to remove particulate matter from waste air streams, may fail as a result of several different types of occurrences. Furthermore, a filter may fail as a result of a large solid object penetrating the filter media, releasing some portion of the entrapped radioactivity to the airstream. The filter may fail as a result of high moisture content of the airstream weakening the filter media, again resulting in the release of radioactivity to the airstream. A third possibility would be a fire or explosion in the HEPA filter vault which could release all of the entrapped radioactivity.

In assessing the various INEL plants, the failure of the HEPA filter at the ICPP calciner appears to represent the worst-case accident. This filter is changed about every nine days. The curie content of an average filter just before changeout is shown in Table III-30.

TABLE III-30

ISOTOPIC BUILDUP ON ICPP WCF FILTER

Nuclide	Curies
Ruthenium-106	185.0
Strontium-90	62.4
Cesium-137	46.8
Cerium-144	19.0

If 100% of the radioactivity shown in Table III-26 were released during unfavorable atmospheric dispersion by fire, explosion, or other mechanism, the maximum offsite dose commitment would be 7 mrem. This dose would result from inhalation of radionuclides within the plume. A backup filtration system (the APS) has now been installed at ICPP (described in Section II.A.3.a) which precludes this accidental release; however, the accident is presented as an upper value reference case.

To reduce the potential for large accidental releases to the atmosphere, those facilities with the potential for high-level releases are equipped with radiation monitors which sample the exhaust stream downstream from the filters. All HEPA filters, through an ERDA-wide program, are required to be tested periodically. The time between tests varies from facility to facility based on use factors. Most of the filtered exhaust streams at INEL have differential pressure-measuring devices across the filter elements which indicate to the operators the filter condition on a continuous basis. When the filters become loaded, they are replaced with new filters, which are tested before the system is put back into operation. The old filters are treated as solid waste and are sent to RWMC for disposal.

Abnormal or accidental releases of gaseous or aerosol radioactivity can be conceived, but they are highly improbable. The rare gas plant at ICPP, while operating to recover krypton-85, could experience an unscheduled process shutdown that could cause liquified krypton-85 (up to 5,000 Ci) to volatilize and be released to the plant atmosphere. If this accident were to happen during unfavorable weather conditions, the maximum offsite wholebody exposure from immersion in the plume would be 0.005 mrem.

2. Nonradioactive Airborne Waste Incidents

The quantities and types of nonradioactive airborne wastes are those common to most industries. No accidents are envisioned which would result in an appreciable impact upon the environment. The nitrogen oxide gases from ICPP represent the maximum quantities of industrial effluents being introduced into the atmosphere at INEL. These gases are released on a continuous basis to the atmosphere through a 250-ft-high stack. Ground-level concentrations do not exceed release guidelines for these gases. There is no holdup of these gases as they are generated; therefore, there is no possibility of abnormally high ground-level concentrations of nitrous oxide gases over what has been monitored and measured for various types of weather conditions which affect concentration.

3. Radioactive Liquid Waste Incidents

Since high-level (content of radioactivity) liquid waste and intermediate- to low-level liquids are controlled and processed separately, they are discussed separately.

a. High-Level Liquid Waste Incidents

(1) Tank Leakage

The only location at INEL where high-level wastes are generated and processed is at ICPP. These wastes are routed for interim storage to 300,000-gallon underground stainless steel tanks which are enclosed in secondary concrete vaults. Stress calculations show that these storage tanks will withstand the maximum earthquake (ground acceleration ≤ 0.33 g) postulated for INEL. Probes within each tank give continuous level readings. The vaults are all equipped with concrete sumps; each sump also has level instrumentation and a level alarm. The alarms sound both in the tank farm control house and in the main process building operating corridor, which is continually manned.

There has been no leakage from the large waste tanks, and no abnormal credible conditions are envisioned which would result in substantial undetected leakage from them. Any leak in excess of approximately 5-10 gallons from a tank would collect immediately in the vault sump and activate the sump alarm. The sump would be sampled before any action would be taken. This sampling would take less than 30 min. If the liquid found in the sump were determined by monitoring not to be waste from the tank (nonradioactive surface water), it would be jetted to the process equipment waste collection system. However, if a leak from the tank had occurred, the sump jet (40 gallons/min capacity) would be activated immediately, to transfer the liquid back into the tank. At the same time, the leaking tank would be emptied by jet to the spare tank (always kept empty as a precautionary measure) so the leak in the tank could be repaired. Each waste tank is equipped with the two steam jets and each jet has a capacity of 40 gallons/min. Therefore, liquid from a waste tank can be removed at a rate of 80 gallons/min, which would empty a 300,000-gallon tank in about 60 hr.

(2) Loss of Cooling to High-Level Liquid Waste Tanks

Cooling coils line the inside walls and floor of the several 300,000-gallon interim storage tanks for high-level liquid wastes. Additionally, water-cooled reflux condensers on each cooled tank vent to the ICPP vessel off-gas system. The off-gas passes through a HEPA-filter bank in the atmospheric protection system.

The cooling coils within each tank are an interconnected system of individual coils. Each coil can be valved into or out of service. Should one coil fail, it simply can be valved out-of-service, and the tank can be cooled by the remaining coils and the reflux condenser.

Rarely is continuous cooling required in the high-level tanks. As a precautionary practice, however, the cooling water is turned on whenever fresh waste is transferred into a tank. Nominally, depending on the age of the fuel being processed, or its average burnup, and on the age and amount of waste already in the tank, the cooling water is turned off again within one month of a fresh addition of waste. If very little or no waste were in a receiving tank before transfer and some fresh waste from dissolving a high-burnup fuel were being generated, it is conceivable that some surface boiling could occur if cooling water were not present.

Absense of cooling water would be discovered by preoperational checks before waste transfer began. This permits the transfer to be switched to another receiving tank which had cooling water. Were all the cooling water to the entire tank farm lost, dissolution of fuel would not be initiated.

Nonetheless, if cooling were lost, the reflux condensers would be the primary safeguard to return condensed vapors to the tanks. Any vapors escaping the reflux condensers would condense in the off-gas line which drains to one of the large storage tanks. Since the off-gas is HEPA-filtered before release to the atmosphere, virtually all entrained fission products would be removed, and no environmental release would be probable.

(3) Transfer Line Leakage

All transfer lines carrying high-level liquid wastes to the interim storage tanks, between tanks, and to the Waste Calcining Facility are stainless steel, doubly-contained, and underground. Sumps along the lines collect any liquid that escapes the transfer line into the secondary containment. These sumps are monitored weekly.

A few leaks in high-level liquid waste lines have been discovered at ICPP. (See items 28 and 29 in Appendix C.) In one active line (currently in use), a leak was discovered during the weekly sump check; the primary containment had failed, but the waste was held by the secondary encasement. The other leaks were discovered in rarely-used or abandoned lines when excavation around the lines was performed. In these cases, the secondary encasement also had been breached. A leak that was discovered in September 1975 (item 29, Appendix C) is considered representative of the maximum leak that could be expected. This leak resulted in the loss of approximately 14,000 gallons of high-level liquid waste which contaminated a subsurface soil zone 150 by 20 ft along a backfilled area of a pipe trench at a depth generally between 12 and 25 ft. The contaminated soil zone is in a controlled, fenced area and has been mapped. It has been left in place since future required excavation in the area has not necessitated the removal of the contaminated soil to RWMC.

A detailed calculational model of the ion-exchanged properties of the soil surrounding the waste lines and tanks has not been developed. The encasement design, sumps, and operating history at ICPP indicate that environmental contamination from leaking waste lines is not a significant hazard. For subsurface contamination, the policy in the future will be to analyze the extent of contamination by probes, then leave the contaminated soil in place if it does not constitute a radiation hazard to plant personnel. Appropriate mounding or surface treatment will be undertaken above the soil body to eliminate possible downward migration of the contamination. If the contamination extends to the surface or to where operational necessity dictates that a soil body be removed, all soil exhibiting a surface reading, within the excavating tool used, of greater than 2.5 mr/hr at 4 in. will be transferred to RWMC.

b. Low- and Intermediate-Level Liquid Waste Incidents

Holdup tanks and basins for the collection and temporary storage of low- and intermediate-level liquid wastes exist at a number of INEL operating facilities. The low- and intermediate-level wastes stored in these tanks are of such a nature that no special shielding is required, as distinguished from high-level wastes. Typically, collected solutions at these tanks or basins are sampled and analyzed.

From the analysis a decision is made, based on the radioactivity and isotopic content, either to transport the waste to a process facility for reduction in volume (usually by an evaporation process) and final storage or to discharge to a pond for settlement and solar evaporation.

Liquid waste process streams at INEL facilities contain only trace quantities of plutonium or other transuranic elements; therefore, the potential for leaks from liquid waste storage involving substantial amounts of transuranic is nonexistent. The potential for accidental leaks does exist, however. Leaks in tanks and holdup basins containing low levels of fission and activation radioactivity have occurred at INEL (see Appendix C). To date no environmental degradation of any consequence has resulted from these minor releases. Soil contamination from leaks which have occurred has been quite localized and confined to relatively small volumes. Area decontamination has consisted of excavating and then transporting the contaminated soil to RWMC. The holdup tanks are of such a volume that the contents can be transferred to safe storage by tank truck if a leak is discovered.

The holdup tanks at TRA are typical of most of the tanks at INEL. These tanks are sampled routinely, and if concentrations exceed discharge limits for routing to a nearby seepage pond, they are shipped to ICPP in a tanker truck for processing. The average concentration of the waste shipped to ICPP is approximately 2.2×10^{-4} Ci/gallon. Assuming that the largest holding tank at TRA (10,000 gallons) was filled with liquid at this concentration and a leak went undetected so that the entire contents were released, a total of 2.2 Ci of radioactivity would be released to the subsoil surrounding the tank. The ion-exchange properties of the soil would act as a filtering medium. Laboratory modeling and experience with settling basins show that, with the exception of tritium, all of the released radionuclides would be expected to be confined to an area within a few feet of the tank. If necessary, this area could be excavated and the contaminated soil sent to RWMC.

4. Nonradioactive Liquid Waste Incidents

Abnormal conditions associated with these systems would not pose an appreciable impact upon the environment. These wastes are routinely routed to disposal wells or surface ponds. A spill prior to reaching the pond or an abnormal amount of chemically contaminated water reaching the pond at any given time would not result in identifiable adverse consequences.

5. Radioactive Solid Waste Incidents

These wastes are represented by the calciner solids stored in stainless steel bins, high-level wastes stored in small welded steel enclosures at EBR-II, transuranic wastes stored in 55-gallon drums at TSA, and wastes buried in trenches and pits at RWMC. The designs of these facilities have provided protection against credible earthquakes, flooding, and other natural phenomena which otherwise would result in loss of container integrity. The wastes at RWMC are, however, in more intimate contact with the environment, and events can be postulated which may result in possible movement of these wastes. Each of the possible abnormal occurrences and postulated effects upon wastes at RWMC are described below.

a. Flooding

Flooding, either from overflow from the Big Lost River, whose channel is 1.5 mi from RWMC, or from local snowmelt on the plain could cause a threat of transportation of the radioactive material contained at RWMC. Future movements of waste by flooding are considered unlikely because of RWMC's location on a large plain. Flooding would result in little flood current. Of far greater concern is flood-induced leaching of radioactive contamination from the waste into the water table.

The Snake River Plain aquifer underlies RWMC at a depth of about 580 ft. To contaminate the water table would require that the radioactivity be carried from near the surface down through soil, basalt, and sedimentary material. These materials act in such a way that even if water from the surface should percolate to the water table, the underground water resources would not necessarily be contaminated. The clay-bearing soils, sediments, and to some extent the basalt beneath INEL exhibit ion-exchange properties; i.e., chemical and physical reactions occur between radioactive isotopes in solution and the elements in the soil in such a way as to bind the radioactive material in the soil and prevent further downward migration. Other factors exist to limit transport of wastes; these include highly stable waste forms (much of the radioactivity is contained in stainless steel or other solid metals which are highly resistant to corrosion), solubility, and acidity. The last two are especially important when considering plutonium waste leaching. Construction requirements for the burial trenches stipulate that at least 2 ft of soil exist between the bottom of the trench and the underlying basalt layer. These factors all work together to mitigate the consequences of a flood.

The threat of major flooding of RWMC from Big Lost River overflow at flood stage is mitigated by a flood control system. Earthfilled embankments constructed in 1958 divert high water to a system of spreading grounds. Although RWMC has never been flooded from the Big Lost River, additional engineering and economic studies are being conducted to improve the flood control system.

b. Earthquake

Although the INEL is in a tectonically active area, seismic activity and fault data show that most of the earthquake activity is in or near the mountains surrounding the Snake River Plain. Some local shaking may accompany distant earthquakes that occur in the mountains, but the safety of the materials at RWMC would not be threatened.

c. Tornado

Although tornadoes are possible in Idaho, their probability of occurrence with enough energy to disrupt RWMC is small. An analysis[114] shows that the 55-gallon drums used to store transuranic contaminated wastes from Rocky Flats will withstand tornado buffeting. Although the effect of a tornado on an uncovered trench could result in lifting and spreading of contaminated contents over extended distances, the spreading would be of low-level activation and fission product types, and the environmental impact of the dispersed radioactivity would not be major.

d. Volcanic Activity

Much of the Snake River Plain has been subjected to both rhyolite and basalt volcanism in the geologic past. It would appear that volcanism can be expected to occur again on the plain, probably along recently active rift zones. The possibility of future caldera related rhyolite eruptions on the Snake River Plain appears to be very remote. Rift controlled basalt eruptions can be expected to occur on the Snake River Plain again. The probability of basalt eruptions occurring within INEL and RWMC in any given year may be on the order of 1 in 10,000.

e. Fire

Since much of the volume of the wastes buried is combustible material, the potential for fire exists. Only three fires have occurred at RWMC in 22 yr of operations and two of these occurred on successive days. They were extinguished with water and by bulldozing soil over the smoldering material. Procedures were then changed to backfill the trenches progressively as waste is added. The third fire occurred in a drum of Rocky Flats waste that was temporarily stacked at RWMC prior to being stored on the TSA pad. The fire was extinguished and the contamination spread was limited to within 10 ft of the drum.

The major concern from fires in the waste is the spread of airborne radioactivity and subsequent fallout and exposure of downwind populated areas. Conservative calculations show that the impact from postulated fires in the waste burial pits would be quite minimal, but a major fire in the plutonium-bearing Rocky Flats waste stored on the TSA pad could result in contamination of the ground within a 1- or 2-mi radius. The cost of decontamination could be substantial; however, the majority of the contamination would be within the site boundary and no agricultural land would be affected. Even though the probability of a fire in conjunction with the 55-gallon drums is low, the risk has been reduced further. The drums containing the transuranic wastes are compartmentized within the TSA to limit the plutonium inventory, and all box storage arrays and wood stacking material are pretreated with a fire resistant coating. In addition, the compartments are separated and covered with soil to reduce the available oxygen and spread of fire, should one occur.

f. Chemical Explosions or Nuclear Criticality

A chemical explosion could cause local contamination spread, but the greater hazard would result from a nuclear-induced fire with consequences like those discussed above. A nuclear criticality accident, caused by an accumulation of sufficient fissile material and moderator in an optimum geometry, is highly unlikely to occur because strict accountability and record requirements ensure that specified fissile material concentrations are not exceeded. The highest permitted concentration of fissile material (plutonium-239) is in the Rocky Flats waste drums stored on the TSA pad. Calculations, using highly conservative assumptions, show that even these storage arrays are grossly subcritical. In addition, the actual quantity of fissile material is far below the permitted concentrations. The environmental consequences from a nuclear criticality, although unlikely, are of the same magnitude as a fire in the plutonium-bearing material as discussed above.

g. Handling and Disposal

Current waste handling procedures at each of the waste management sites are designed to retain radioactive contamination during handling. It is conceivable, however, that burrowing animals might become contaminated by contacting buried waste. It is also conceivable that minute amounts, which are now undetectable, might in the future contaminate the immediate land surface adjacent to RWMC to the extent that the accumulation might become detectable. This accumulation could result from windblown radioactivity, flooding in the area, and transport by small animals. Samples of soil around RWMC will continue to be taken to identify any buildup of radionuclides in surface soils.

6. Nonradioactive Solid Waste Incidents

These wastes currently are disposed of in a sanitary landfill. As most of the waste is combustible, a fire is possible. The consequence of a fire would be minor and limited to the combustion of a day's accumulation of scrap material. (The sanitary landfill is covered on a daily basis.) During the placement of wastes in the sanitary landfill, high winds also can be a mechanism for scattering paper and other windblown debris in the immediate area. This mechanism is being controlled by a 4-ft-high fence.

7. Handling and Transportation Incidents

Abnormal circumstances could result in accidents during handling and transport of waste materials at INEL. Accidents could occur while moving solid radioactive waste from facilities to RWMC. These accidents could be initiated by a fire in the transport container, collision of the transport vehicle, or loss of container from a transport vehicle.

A fire in a transport container would occur most likely in the routine contaminated trash transported to RWMC in Dempster dumpsters.

These wastes normally contain combustibles, but an ignition source is not readily identifiable. However, if a fire were to occur, the consequences could be severe. On an INEL-wide basis there is an average of one shipment per day of this type waste. An average shipment contains 0.31 Ci of radioactivity. The radioactivity in the low-level solid waste is a combination of mixed fission and activation products. There are no identifiable actinides in the waste. However, high-radiation inhalation exposures (>5000 rem) could result to the driver of the transport vehicle if he remained downwind and inhaled the contents of the plume for a significant period (30 min). This postulated exposure results mainly from the strontium-90 component of the waste, assuming it became airborne. In all probability the driver of the transport vehicle would notice the smoke from the fire, stop the truck, take protective action from the smoke plume, and receive no exposure. Even if all the radioactivity were released to the atmosphere, the impact upon the land would probably be local and amenable to decontamination. The 0.31 Ci is also only a fraction of the small amount of particulate radioactivity now being routinely released to the atmosphere from stacks at INEL plants.

An accident could also be postulated during the transfer of shielded casks containing waste materials of high radioactivity. The maximum credible accident results from a motor vehicle accident in which the shielded cask (container) is broken open and the contents spilled. No releases of gaseous activity would be involved. The accident at most would contaminate the local area where the spill occurred. High dose rates could be encountered by workers during repositioning of the spilled material into another container. Radiation levels as high as 25 to 30 R/hr at 6 ft from the source could be expected.

The transfer of liquid wastes in a tanker truck also is a source of accidental spill of radionuclides. These low-level liquid wastes are shipped routinely from TRA to ICPP. Approximately 20 shipments, containing an average of 6,000 gallons and 1.3 Ci of radioactivity, are made each year. Spillage during loading, unloading, or an accident enroute could be postulated. These accidents would not result in airborne radioactivity, and contamination would be limited to the area of the spill. The radiation level in the area of the spill in all probability would be less than 20 mR/hr. The moist ground in the vicinity of the spill could be easily removed and replaced with uncontaminated soil. Any impact would be local in nature.